FISCAL YEAR 1991 DEPARTMENT OF ENERGY AUTHORIZATION

(Fossil Energy)

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

SECOND SESSION

JUNE 20, 1990

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1991 DEPARTMENT OF ENERGY AUTHORIZATION

WEDNESDAY, JUNE 20, 1990

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Energy Research and Development,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:35 a.m., in room 2318, Rayburn House Office Building, Hon. Rick Boucher (acting Chairman of the subcommittee) presiding.

OPENING STATEMENT OF HON. RICK BOUCHER, SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Mr. **Boucher**. The Subcommittee will come to order.

Before we begin the hearing this morning, the chair asked unanimous consent that today's proceedings be permitted to be recorded and otherwise covered by the electronic media, and without objection that is so ordered.

This morning, the Subcommittee will receive a budget overview from the Department of Energy on its fiscal year 1991 budget submission for Fossil Energy Research and Development. Beyond that, outside witnesses will provide us with their comments on the budget as it relates to their research and development activities.

The budget submission for Fossil Research and Development programs is $202 million for Fiscal Year 1991. That is a 51 percent decrease from the fiscal year 1990 appropriated levels. The major decrease in funding most severely affects coal research and development activities. The $110 million proposed for coal is a 60 percent decrease from ongoing levels.

I personally am very concerned that that low budget for coal research and development, if approved, would have a very substantial adverse affect on the ability of our Nation to continue to use coal in an environmentally benign manner.

While the largest decreases are recommended for MHD, that is a 100 percent decrease, and for fuel cells, an 81 percent decrease, I'm also quite concerned about the decreases recommended for the category of heat engines, that's −71 percent, coal liquefaction, −69 percent, and surface coal gasification, −64 percent.

The submission for oil and gas programs are about equal to the current appropriated levels. In addition to a level funding request, the Department has submitted three new program plans for geosciences research, oil and gas. The three plans signify a new focus for these efforts, moving from long term returns to more near term kinds of activities. I look forward to hearing additional information on the implementation plans from this morning's witness, Secretary Gentile.

[The prepared opening statement of Mr. Boucher follows:]

HONORABLE RICK BOUCHER

OPENING REMARKS
DEPARTMENT OF ENERGY'S FY 1991
FOSSIL ENERGY BUDGET REQUEST

JUNE 20, 1990

THE SUBCOMMITTEE WILL COME TO ORDER.

BEFORE WE BEGIN TODAY, I DO ASK UNANIMOUS CONSENT THAT THE SUBCOMMITTEE PERMIT TODAY'S PROCEEDINGS TO BE RECORDED AND COVERED BY THE MEDIA AND OTHER PERSONS, AND WITHOUT OBJECTION, SO ORDERED.

THIS MORNING WE WILL RECEIVE A BUDGET OVERVIEW FROM THE DEPARTMENT OF ENERGY ON THEIR FY 1991 BUDGET SUBMISSION FOR FOSSIL RESEARCH AND DEVELOPMENT. IN ADDITION, OUTSIDE WITNESSES WILL PROVIDE US WITH

THEIR COMMENTS ON THE BUDGET AS IT RELATES TO THEIR RESEARCH AND DEVELOPMENT ACTIVITIES.

THE BUDGET SUBMISSION FOR FOSSIL RESEARCH AND DEVELOPMENT PROGRAMS IS $202 MILLION FOR FY 1991, A 51% DECREASE FROM FY 1990 APPROPRIATED LEVELS. THE MAJOR DECREASE IN FUNDING ALLOCATION MOST SEVERELY IMPACTS COAL R&D ACTIVITIES. THE $110 MILLION PROPOSED FOR COAL IS A 60% DECREASE FROM ONGOING LEVELS. I AM CONCERNED THAT THE LOW BUDGET LEVEL, IF APPROVED, WILL HAVE AN EXTREMELY DETRIMENTAL AFFECT ON OUR NATION'S ABILITY TO CONTINUE UTILIZING OUR ABUNDANT COAL RESOURCES IN AN ENVIRONMENTALLY BENIGN MANNER. WHILE THE LARGEST DECREASES ARE RECOMMENDED FOR MHD (-100%) AND FUEL CELLS (-81%), I AM ALSO CONCERNED ABOUT HEAT ENGINES(-71%), COAL LIQUEFACTION (-69%), AND SURFACE COAL GASIFICATION (-64%).

THE SUBMISSION FOR OIL AND GAS PROGRAMS ARE ABOUT

EQUAL TO LAST YEAR'S APPROPRIATED LEVELS. IN ADDITION TO A LEVEL FUNDING REQUEST THE DEPARTMENT HAS SUBMITTED THREE NEW PROGRAM PLANS FOR GEOSCIENCES RESEARCH, OIL, AND GAS. THE THREE PLANS SIGNIFY A NEW FOCUS FOR THESE EFFORTS -- MOVING FROM NOT ONLY LONG-TERM POTENTIAL PAYOFF BUT ALSO TO NEAR-TERM ACTIVITIES. I LOOK FORWARD TO HEARING ADDITIONAL INFORMATION ON THE IMPLEMENTATION PLANS FROM ASSISTANT SECRETARY GENTILE.

BEFORE WE CONTINUE I WOULD LIKE TO RECOGNIZE THE HON. SID MORRISON, THE RANKING REPUBLICAN OF OUR SUBCOMMITTEE, FOR HIS OPENING STATEMENT.

WOULD OTHER MEMBERS CARE TO MAKE AN OPENING STATEMENT?

OUR FIRST WITNESS IS THE HON. ROBERT GENTILE, THE ASSISTANT SECRETARY FOR FOSSIL ENERGY AT THE

DEPARTMENT OF ENERGY. THIS IS MR. GENTILE'S FIRST TIME BEFORE OUR SUBCOMMITTEE AND I WOULD LIKE TO WELCOME HIM. MR. GENTILE PLEASE PROCEED.

Mr. BOUCHER. Before we continue, I would like to recognize the Ranking Minority Member of the Subcommittee for his opening statement, the gentleman from Washington, Mr. Morrison.

OPENING STATEMENT OF HON. SID MORRISON, RANKING REPUBLICAN, SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Mr. MORRISON. Thank you, Mr. Chairman.

Today we're reviewing the Administration's budget request for fossil energy. I think that our efforts to increase the use of clean coal, as well as to increase the availability of oil and natural gas resources, are very important, because our Nation depends on fossil energy for almost 90 percent of the total energy requirements.

I can see that our fossil energy R&D program invests heavily in coal technology development, because coal is the largest domestic fossil energy resource and is relatively underutilized. I am pleased with the progress made in the Clean Coal Technology Program, but I'd like to hear more about the DOE proposal to stretch out the schedule on this program.

As our Chairman has just pointed out, the budget request is again less than half of the prior year appropriations. I saw nothing in the Secretary's written statement about the impact on program direction, priorities, scope and schedule, and I'm anxious to hear the Secretary's views on these topics as well as on the recently published implementation plans and strategy of such programs.

I look forward to the testimony today, Mr. Chairman, and working with you.

[The prepared opening statement of Mr. Morrison follows:]

HON. SID MORRISON (R-WA)

OPENING STATEMENT
FY 1991 DOE AUTHORIZATION - FOSSIL ENERGY R&D

JUNE 20, 1990

GOOD MORNING. TODAY WE ARE REVIEWING THE ADMINISTRATION'S BUDGET REQUEST FOR FOSSIL ENERGY. I THINK OUR EFFORTS TO INCREASE THE USE OF CLEAN COAL, AS WELL AS TO INCREASE THE AVAILABILITY OF OIL AND NATURAL GAS RESOURCES ARE VERY IMPORTANT, BECAUSE OUR NATION DEPENDS ON FOSSIL ENERGY FOR ALMOST 90% OF THE TOTAL ENERGY REQUIREMENTS.

I CAN SEE THAT OUR FOSSIL ENERGY R&D PROGRAM INVESTS HEAVILY IN COAL TECHNOLOGY DEVELOPMENT, BECAUSE COAL IS THE LARGEST DOMESTIC FOSSIL ENERGY RESOURCE AND IS RELATIVELY UNDERUTILIZED. I AM PLEASED WITH THE PROGRESS MADE IN THE CLEAN COAL TECHNOLOGY PROGRAM, AND I WOULD LIKE TO HEAR MORE ABOUT THE DOE PROPOSAL TO STRETCH OUT THE SCHEDULE OF THIS PROGRAM.

AS OUR CHAIRMAN HAS JUST POINTED OUT, THE BUDGET REQUEST IS AGAIN LESS THAN HALF OF THE PRIOR YEAR APPROPRIATIONS. I SAW NOTHING IN SECRETARY GENTILE'S WRITTEN STATEMENT ABOUT THE IMPACT ON PROGRAM DIRECTION, PRIORITIES, SCOPE, AND SCHEDULE, AND I AM ANXIOUS TO HEAR THE SECRETARY'S VIEWS ON THESE TOPICS, AS WELL AS ON THE RECENTLY PUBLISHED IMPLEMENTATION PLANS AND STRATEGY OF YOUR PROGRAMS.

I LOOK FORWARD TO THE TESTIMONY FROM OUR DISTINGUISHED WITNESS TEAM TODAY.

Mr. **Boucher**. The chair thanks the gentleman.

The gentleman from Illinois, Mr. Fawell?

Mr. **Fawell**. Thank you, Mr. Chairman.

I, at the outset, must give my apologies for having to leave very shortly. I have an Education and Labor Committee hearing where I am playing a sort of pivotal part, so I regret that I can't be here to listen to all the testimony, although I will review the submitted testimony.

Especially I would like to greet Frank Schora, who is President of M-C Power Corporation, which happens to be located in the center place of the universe out in DuPage County, Illinois, but I don't think Frank is here as yet. Perhaps if he does come in the second panel, if one could at least mention that I mentioned him and I'm sorry that I cannot greet him. So I will be here for a short period of time but regret that I must leave in five or ten minutes.

Thank you, Mr. Chairman.

Mr. **Boucher**. The gentleman from Texas, Mr. Smith?

OPENING STATEMENT OF HON. LAMAR SMITH, SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Mr. **Smith**. Thank you, Mr. Chairman.

I would like to convey this morning to the Committee my strong support for the Oil Research Program implementation plan as recently submitted to the Subcommittee by the Department of Energy. I look forward to securing the necessary funding for this vital plan. Time is critical.

Currently, the accelerating rate of capping wells could result in the Nation losing economic access to as much as two-thirds of its oil reserves by 1995. The DOE plan details the need. It states, "The United States has produced more oil than any other nation in history, but unless new technologies are rapidly developed and installed, the U.S. will leave behind twice as much oil in known reservoirs as it has ever produced from them."

The plan also spells out the promise, if timely action is taken, to get new cost effective technologies into the oil and gas field. It reads, "Of this, the Nation's massive 340 billion barrel resource, as much as 76 billion barrels could be made economically producible using technologies that could be developed within the next decade."

Our goal must be to maximize economic access to our domestic oil reserves. We must do that before current costs force producers to plug currently operating wells, sealing off cost effective access.

The Oil Research Program implementation plan addresses this problem facing the U.S. oil industry in a three-pronged approach. In the near term, over the next five years, the plan focuses on preserving access to defined high potential oil field classes that are rapidly approaching their economic limits of producibility. It is through such an effort that our rapid rate of oil well abandonments might be curved.

In a Federal, State and industry partnership, pilot projects would be established throughout the Nation that would demonstrate to independent producers those technologies which have proven effective in economically extending the life of the well.

In the mid-term, in the next 10 years, the plan is to develop and transfer the best currently defined advanced recovery techniques to operators in the high priority reservoir class. This should enable the benefits of Government-sponsored research and demonstration projects to be transferred to private operators in a timely manner.

In the long term, beyond the next 10 years, the plan is to develop advanced methods of oil recovery that would significantly increase the yield over mid-term technologies. These three objectives, pursued simultaneously, would promote the U.S. oil industry in both the near and long term. Only through fully utilizing the United States' unrecovered oil reserves will we be assured domestic energy security during the coming decades.

By classifying the Nation's oil reserves in terms of those with the greatest recovery potential, we may focus our research and development efforts towards those oil fields which promise the greatest return. The Department of Energy benefit analysis suggests that with a 15-year program cost of $600 million, this research and development program, if successful, has the potential of creating over 300,000 jobs.

Furthermore, the production of this additional resource would improve the balance of payments by eliminating over $2 trillion that would otherwise be paid for imports. In short, it is a very cost effective program. This program appears to me to be just the type of thinking we need more of when considering energy research and development plans.

Programs which consist of both near term and long term benefits to our energy producers should set the standards for future research efforts.

Thank you, Mr. Chairman.

[The prepared opening statements of Mr. Smith and Mr. Costello follow:]

Statement by

Lamar Smith (R-TX)

Before the
Energy Research and Development Subcommittee

June 20, 1990

I would like to convey to the Committee my strong support for the Oil Research Program Implementation Plan as recently submitted to the Subcommittee by the Department of Energy (DOE). I look forward to securing the necessary funding for this vital plan.

Time is critical.

Currently, the accelerating rate of capping wells could result in the nation losing economic access to as much as two-thirds of its oil reserves by 1995.

The DOE plan details the need. It states:

> "The United States has produced more oil than any other nation in history but, unless new technologies are rapidly developed and installed, the U.S. will leave behind twice as much oil in known reservoirs as it has ever produced from them."

The Plan also spells out the promise if timely action is taken to get new cost-effective technologies into the oil and gas fields. It reads:

> "Of this (the nation's) massive, 340-billion-barrel resource, as much as 76 billion barrels could be made economically producible using technologies that could be developed within the next decade."

Our goal must be to maximize economic access to our domestic oil reserves. We must do that before current costs force producers to plug currently operating wells, sealing off cost-effective access.

The Oil Research Program Implementation Plan addresses this problem facing the U.S. oil industry in a three-pronged approach.

In the near term, or the next five years, the plan focuses on preserving access to defined, high potential oil field classes that are rapidly approaching their economic limits of producibility. It is through such an effort that our rapid rate of oil well abandonments might be curbed.

In a federal, state, and industry partnership, pilot projects would be established throughout the nation that would demonstrate to independent producers those technologies which have proven effective in economically extending the life of the well.

In the mid term, or the next ten years, the plan is to develop and transfer the best currently defined, advanced recovery techniques to operators in the high priority reservoir class. This should enable the benefits of government-sponsored research and demonstration projects to be transferred to private operators in a timely manner.

In the long term, beyond the next 10 years, the plan is to develop advanced methods of oil recovery that would significantly increase the yield over mid-term technologies.

These three objectives pursued simultaneously would promote the U.S. oil industry in both the near and long term. Only through fully utilizing the United States unrecovered oil reserves will we be assured domestic energy security during the coming decades.

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This program appears to me to be just the type of thinking we need more of when considering energy research and development plans. Programs which consist of both near-term and long-term benefits to our energy producers should set the standards for future research efforts.

OPENING STATEMENT
BY U.S. REP. JERRY F. COSTELLO
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY, RESEARCH AND DEVELOPMENT
FOSSIL R&D FY 1991 BUDGET OVERVIEW
JUNE 20, 1990

Madame Chairman, today we welcome our very distinguished witnesses to discuss the Department of Energy's FY 1991 budget request for fossil research and development activities.

As we consider the problems of increased energy demand, energy dependence and environmental phenomena such as acid rain and global warming, we must investigate the potential of fossil energy as an alternative source of electricity.

I look forward to hearing our witnesses testify as to the reasons for and effects of funding priorities as expressed in the budget proposal.

Madame Chairman, I thank you for calling this hearing and I anticipate some interesting and relevant commentary by our distinguished witnesses.

Mr. **Boucher**. The chair thanks the gentleman and is pleased to welcome to the Subcommittee this morning in his first appearance before our group the U.S. Department of Energy's Assistant Secretary for Fossil Fuels, who I got to know well and worked with very effectively during his tenure as Director of the Office of Surface Mining.

We're quite pleased to welcome the Assistant Secretary this morning, Bob Gentile, and we'll be happy to receive your testimony.

STATEMENT OF HON. ROBERT H. GENTILE, ASSISTANT SECRETARY FOR FOSSIL ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY JEREMIAH WALSH, DEPUTY ASSISTANT SECRETARY FOR MANAGEMENT; JACK SIEGEL, DEPUTY ASSISTANT SECRETARY FOR COAL TECHNOLOGY; AND MARVIN SINGER, DEPUTY ASSISTANT SECRETARY FOR OIL AND GAS SHALE AND SPECIAL TECHNOLOGIES

Mr. **Gentile**. Thank you, Mr. Chairman.

I would like to submit my formal statement for the record, Mr. Chairman, but I would like——

Mr. **Boucher**. Without objection, that will be made a part of the record.

Mr. **Gentile**. Thank you. With me today are Mr. Jeremiah Walsh, my Deputy Assistant Secretary for Management; Mr. Jack Siegel, my Deputy Assistant Secretary for Coal Technology; and Mr. Marvin Singer, my Deputy Assistant Secretary for Oil, and Gas, Shale and Special Technologies. I have some other staff members behind that I may call upon, with the chair's permission, to answer specific questions.

Let me begin by addressing specifically the points that were included in the chairman's letter of invitation. Our budget requests for Fossil Energy R&D is $202.3 million. Although this request is significantly less than last year's appropriation, it does reflect an attempt by the Department to bring its coal, oil and gas programs into better balance.

Specifically, we have raised the level of funding for oil and gas extraction technology. The funding requested for these programs now closely approximates that provided in recent years by Congress.

Fiscal year 1991, Mr. Chairman, represents the final year of transition from an oil and gas program that has been heavily oriented toward longer term research to one that focuses on much shorter term objectives.

Specifically, in the nearer term, we have underway an aggressive effort to characterize the Nation's oil reservoirs into classes with similar geologic ancestry. This, we believe, is a critical and necessary first step in developing strategies that can prevent or slow the premature abandonment of marginal wells and fields with high remaining production potential.

We already have extensive data for three States. By the end of this fiscal year, we will have added data for most of the lower 48 onshore resource, with the exception of Appalachia. The final step will be to incorporate the Appalachian reservoirs, as well as those reservoirs of both Alaska and offshore. We expect to have this done by October of 1992.

As information is developed in each of these high priority reservoir classes, we will hold technical meetings to determine the obstacles that exist in each class. In other words, what is causing the high rates of oil abandonment, and what can be done to prolong the life of those fields.

Much of the $17 million in the geoscience initiative that you referred to in your letter to the Committee will be used for the next step—to take the information gains from this reservoir characterization effort and to begin applying it in the field.

The largest increment, that of $10 million, is in the Enhanced Oil Recovery Program, with the goal of initiating field efforts in the high priority reservoir classes—those reservoirs that have substantial qualities of remaining oil in place but face near term risk of abandonment.

The Gas Program contains a request for $4 million, with the goal of developing a more detailed, comprehensive assessment of our gas resource, bringing the data base up to the same level that now exists for oil. This will give us the information needed to determine where additional extraction research, both for conventional and unconventional gas reservoirs, might be best applied.

The last increment, $3 million, is in the Advanced Extraction and Process Technology Program. These funds will be used for fundamental supporting research that's relevant to both oil and gas.

The $17 million geoscience initiative will be cost-shared competitively by selected consortia, and it will be to ensure that our oil and gas programs are being developed and executed in direct response to the needs of industry and that our program has the benefits and can serve as a conduit of the expertise that exists within our university community and our State geologic network.

If Congress supports this approach, we'll be prepared in fiscal year 1991 to issue one or more competitive procurements. These procurements would define specifically the field and supporting work to be done by a consortia of producers, service organizations, universities, and State agencies.

Turning to coal, the coal R&D budget proposal also reflects a shift toward near term objectives. Within the $110 million request, you will see funding for efforts that could offer further improvements in the acid rain control technologies now in the demonstration phase. You will see the beginnings of new efforts to concentrate on high efficiency systems as a way to reduce CO2 build-up from the power-generating industry.

We're also continuing our efforts to develop technologies that can open new markets for coal and coal products. For example, funding requested for new fluidized bed combustors and alternative fuels are directed at restoring the clean burning coal option to the light industrial, commercial and residential sectors. Programs geared to the transportation sector are found in the coal liquefaction, surface coal gasification and heat engines programs.

Our budget request for the Clean Coal Technology Program is $456 million. It includes the last increment of funding for rounds two and three and the first year of funding for round four. The major distinction in this budget compared to the 1990 clean coal budget is a stretch-out of budget authority for rounds four and five.

When the budget was prepared, the stretch-out of funding was not anticipated to have any effect on either the pace or the number of future clean coal projects. Round four would have proceeded on schedule with the issuance of a competitive procurement on June 1.

However, as you're aware, Mr. Chairman, the Congress has directed us to defer the fourth round of clean coal competition. At the same time, actions by the House in approving the clean air legislation could severely alter the scope and the purpose of the final two rounds of the Clean Coal Program.

Section 515(e) of the Clean Air Amendments would limit rounds four and five of the Clean Coal Program to only 20 percent of the Nation's utilities. It would restrict future projects to only a limited region of the country. It would buy us further competitions toward nearer term technologies and away from the longer term high efficiency concepts that would be crucial for coal use in the 21st century. And it would arbitrarily preclude industrial coal-fired facilities, co-generators, independent power producers, and any other non-utility user from participating in the program.

We're extremely concerned that such actions could have a serious detrimental impact on the Clean Coal Program and on the long term future of coal use in this country. I know that this Subcommittee is considering a hearing specifically on this issue, Mr. Chairman, but let me use this opportunity to urge you and Members of the Committee to take what action you can to restore the Clean Coal Program to its original purpose and scope.

Both the Administration and Congress have been strong supporters of the Clean Coal Program to date. The budget request we're discussing today continues that support. That completes my opening statement, Mr. Chairman, and I'd be pleased to answer any questions.

[The opening prepared statement of Mr. Gentile follows:]

OPENING STATEMENT

OF

ROBERT H. GENTILE
ASSISTANT SECRETARY FOR FOSSIL ENERGY
U.S. DEPARTMENT OF ENERGY

TO THE

SUBCOMMITTEE ON RESEARCH AND DEVELOPMENT
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

ON

JUNE 20, 1990

MADAM CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE. I AM ACCOMPANIED TODAY BY:

MR. JEREMIAH WALSH, MY DEPUTY ASSISTANT SECRETARY FOR MANAGEMENT,

MR. JACK SIEGEL, MY DEPUTY ASSISTANT SECRETARY FOR COAL TECHNOLOGY,

AND

MR. MARVIN SINGER, MY DEPUTY ASSISTANT SECRETARY FOR OIL, GAS, SHALE AND SPECIAL TECHNOLOGIES.

I HAVE OTHER STAFF MEMBERS BEHIND ME THAT I MAY CALL UPON, WITH THE CHAIR'S PERMISSION, TO ANSWER SPECIFIC QUESTIONS.

LET ME BEGIN BY ADDRESSING SPECIFICALLY THE POINTS THAT WERE INCLUDED IN YOUR LETTER OF INVITATION, MADAM CHAIRMAN.

OUR BUDGET REQUEST FOR FOSSIL ENERGY R&D IS $202.3 MILLION. ALTHOUGH THIS REQUEST IS SIGNIFICANTLY LESS THAN LAST YEAR'S APPROPRIATIONS, IT DOES REFLECT AN ATTEMPT BY THE DEPARTMENT TO BRING ITS COAL, OIL AND GAS PROGRAMS INTO BETTER BALANCE.

SPECIFICALLY, WE HAVE RAISED THE LEVEL OF FUNDING FOR OIL AND GAS EXTRACTION TECHNOLOGY. THE FUNDING REQUESTED FOR THESE PROGRAMS NOW CLOSELY APPROXIMATES THAT PROVIDED IN RECENT YEARS BY CONGRESS.

FISCAL YEAR 1991, MADAM CHAIRMAN, REPRESENTS THE FINAL YEAR OF TRANSITION FROM AN OIL AND GAS PROGRAM THAT HAS BEEN HEAVILY ORIENTED TOWARD LONGER-TERM RESEARCH TO ONE THAT FOCUSES ON MUCH SHORTER TERM OBJECTIVES.

SPECIFICALLY, IN THE NEAR-TERM, WE HAVE UNDERWAY AN AGGRESSIVE EFFORT TO CHARACTERIZE THE NATION'S OIL RESERVOIRS INTO CLASSES WITH SIMILAR GEOLOGIC ANCESTORY. THIS, WE BELIEVE, IS A CRITICAL AND NECESSARY FIRST STEP IN DEVELOPING STRATEGIES THAT CAN PREVENT OR SLOW THE PREMATURE ABANDONMENT OF MARGINAL WELLS IN FIELDS WITH HIGH REMAINING PRODUCTION POTENTIAL.

WE ALREADY HAVE EXTENSIVE DATA FOR THREE STATES. BY THE END OF THIS FISCAL YEAR, WE WILL HAVE ADDED DATA FOR MOST OF THE LOWER-48 ONSHORE RESOURCE WITH THE EXCEPTION OF APPALACHIA. THE FINAL STEP WILL BE TO INCORPORATE THE APPALACHIAN RESERVOIRS, AS WELL AS THOSE IN ALASKA AND OFFSHORE. WE EXPECT TO HAVE THIS DONE BY OCTOBER 1992.

As information is developed in each high priority reservoir class, we will hold technical meetings to determine the obstacles that exist in that class -- in other words, what is causing the high rates of well abandonment, and what can be done to prolong the life of these fields?

Much of the $17 million geoscience initiative that you referenced in your letter, Madam Chairman, will be used for the next step -- to take the information gained from this reservoir characterization effort and begin applying it in the field.

The largest increment, $10 million, is in the Enhanced Oil Recovery program with the goal of initiating field efforts in high priority reservoir classes -- those reservoirs that have substantial quantities of remaining oil-in-place but face the near-term risk of abandonment.

The gas program contains a request for $4 million with the goal of developing a more detailed, comprehensive assessment of our gas resource -- bringing the data base up to the same level as now exists for oil.

THIS WILL GIVE US THE INFORMATION NEEDED TO DETERMINE WHERE ADDITIONAL EXTRACTION RESEARCH -- BOTH FOR CONVENTIONAL AND UNCONVENTIONAL GAS RESERVOIRS -- MIGHT BE BEST APPLIED.

THE LAST INCREMENT, $3 MILLION, IS IN THE ADVANCED EXTRACTION AND PROCESS TECHNOLOGY PROGRAM. THESE FUNDS WILL BE USED FOR FUNDAMENTAL SUPPORTING RESEARCH THAT IS RELEVANT TO BOTH OIL AND GAS.

THE $17 MILLION GEOSCIENCE INITIATIVE WILL BE COST-SHARED WITH COMPETITIVELY SELECTED CONSORTIA. IT WILL HELP ENSURE THAT OUR OIL AND GAS PROGRAMS ARE BEING DEVELOPED AND EXECUTED IN DIRECT RESPONSE TO THE NEEDS OF THE INDUSTRY, AND THAT OUR PROGRAM HAS THE BENEFITS -- AND CAN SERVE AS A CONDUIT -- OF THE EXPERTISE THAT EXISTS WITHIN OUR UNIVERSITY COMMUNITY AND STATE GEOLOGIC NETWORK.

IF CONGRESS SUPPORTS THIS APPROACH, WE WILL BE PREPARED IN FY91 TO ISSUE ONE OR MORE COMPETITIVE PROCUREMENTS. THESE PROCUREMENTS WOULD DEFINE SPECIFICALLY THE FIELD AND SUPPORTING WORK TO BE DONE BY CONSORTIA OF PRODUCERS, SERVICE ORGANIZATIONS, UNIVERSITIES AND STATE AGENCIES.

THE COAL R&D BUDGET PROPOSAL ALSO REFLECTS A SHIFT TOWARD NEARER-TERM OBJECTIVES. WITHIN THE $110 MILLION REQUEST, YOU WILL SEE FUNDING FOR EFFORTS THAT COULD OFFER FURTHER IMPROVEMENTS TO THE ACID RAIN CONTROL TECHNOLOGIES NOW IN THE DEMONSTRATION PHASE. YOU WILL SEE THE BEGINNINGS OF NEW EFFORTS TO CONCENTRATE ON HIGH EFFICIENCY SYSTEMS AS A WAY TO REDUCE CO2 BUILDUP FROM THE POWER GENERATING INDUSTRY.

WE ARE ALSO CONTINUING EFFORTS TO DEVELOP TECHNOLOGIES THAT CAN OPEN NEW MARKETS FOR COAL AND COAL PRODUCTS. FOR EXAMPLE, FUNDING REQUESTED FOR NEW FLUIDIZED BED COMBUSTORS AND ALTERNATIVE FUELS ARE DIRECTED AT RESTORING THE CLEAN-BURNING COAL OPTION TO THE LIGHT INDUSTRIAL, COMMERCIAL AND RESIDENTIAL SECTORS. PROGRAMS GEARED TO THE TRANSPORTATION SECTOR ARE FOUND WITHIN THE COAL LIQUEFACTION, SURFACE COAL GASIFICATION AND HEAT ENGINES PROGRAMS.

CLEAN COAL

OUR BUDGET REQUEST FOR THE CLEAN COAL TECHNOLOGY PROGRAM IS $456 MILLION. IT INCLUDES THE LAST INCREMENT OF FUNDING FOR ROUNDS 2 AND 3 AND THE FIRST YEAR OF FUNDING FOR ROUND 4.

THE MAJOR DISTINCTION IN THIS BUDGET COMPARED TO THE 1990 CLEAN COAL BUDGET IS THE STRETCH OUT OF BUDGET AUTHORITY FOR ROUNDS 4 AND 5. WHEN THE BUDGET WAS PREPARED, THE STRETCH OUT OF FUNDING WAS NOT ANTICIPATED TO HAVE ANY AFFECT ON EITHER THE PACE OR THE NUMBER OF FUTURE CLEAN COAL PROJECTS. ROUND 4 WOULD HAVE PROCEEDED ON SCHEDULE, WITH THE ISSUANCE OF A COMPETITIVE PROCUREMENT ON JUNE 1.

HOWEVER, AS YOU ARE AWARE, MADAM CHAIRMAN, THE CONGRESS HAS DIRECTED US TO DEFER THE FOURTH ROUND OF CLEAN COAL COMPETITION. AT THE SAME TIME, ACTIONS BY THE HOUSE IN APPROVING CLEAN AIR LEGISLATION WOULD SEVERELY ALTER THE SCOPE AND PURPOSE OF THE FINAL TWO ROUNDS OF THE CLEAN COAL PROGRAM.

SECTION 515(E) OF THE CLEAN AIR AMENDMENTS WOULD LIMIT ROUNDS 4 AND 5 OF THE CLEAN COAL PROGRAM TO ONLY 20 PERCENT OF THE NATION'S UTILITIES. IT WOULD RESTRICT FUTURE PROJECTS TO ONLY A LIMITED REGION OF THE COUNTRY. IT WOULD BIAS FUTURE COMPETITIONS TOWARD NEARER-TERM TECHNOLOGIES AND AWAY FROM THE LONGER-TERM, HIGHER-EFFICIENCY CONCEPTS THAT WILL BE CRUCIAL FOR COAL USE IN THE 21ST CENTURY.

And it would arbitrarily preclude industrial coal-fired facilities, cogenerators and independent power producers, and any other non-utility coal user from participating in the program.

We are extremely concerned that such actions could have a serious detrimental impact on the Clean Coal program and on the long-term future of coal use in this country.

I know that this subcommittee is considering a hearing specifically on this issue, Madam Chairman, but let me use this opportunity to urge you and members of the committee to take what action you can to restore the Clean Coal program to its original purpose and scope.

Both the Administration and the Congress have been strong supporters of the Clean Coal program to date. The budget request we are discussing today continues that support.

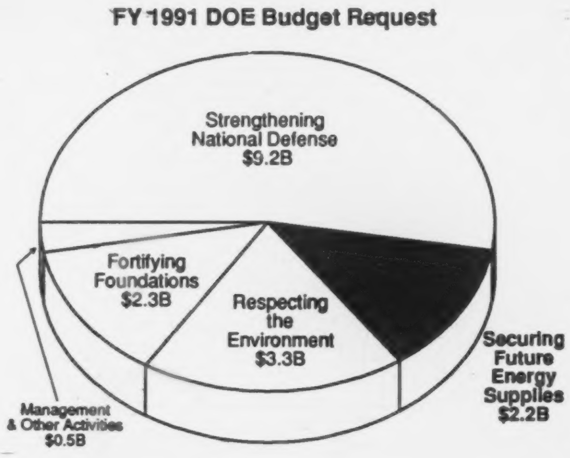
That completes my opening statement, Madam Chairman. I will be pleased to answer any questions you or members of the subcommittee may have.

Statement of Robert H. Gentile
Assistant Secretary for Fossil Energy
U.S. Department of Energy
to the
House Committee on Science, Space and Technology
Subcommittee on Research and Development

Madam Chairman and members of the Committee, I am pleased to present the FY 1991 budget request for Fossil Energy-related programs.

At the President's direction, the Secretary of Energy has initiated the development of a National Energy Strategy (NES). The strategy is designed to provide direction for the Department's future policy and funding initiatives. It will provide a comprehensive, long-range strategy for addressing the Nation's near, mid and long term energy needs. The strategy will be based on public input through hearings, written submissions and publicly available reports, all aimed at reconciling our need for secure, competitively priced supplies of energy with environmental, safety and health requirements. The NES Interim Report that we transmitted to you on April 2 contains some important messages from the people of this country. Later this year, the Department will conduct additional hearings to identify the appropriate options to recommend to the President in our final report in December.

Of the $2.2 billion earmarked for "Securing Future Energy Supplies" in the Department of Energy's fiscal 1991 budget request, $658 million is proposed for fossil energy related technologies — i.e. for advanced processes that can extract more effectively or use more cleanly and efficiently the nation's supplies of coal, petroleum and natural gas.



This funding request is allocated among two major components:

The Clean Coal Technology Program — FY 1991 request: $456 million;

The Fossil Energy R&D Program — FY 1991 request: $202.3 million.

Fossil fuels currently account for almost 89% of U.S. energy consumption. Even if we adopt more aggressive energy conservation and efficiency measures, make greater use of solar and renewable energy resources, and restore the nuclear power option — all of which are necessary to a balanced, more secure energy future — fossil fuels will continue to supply most of the nation's energy needs well into the next century. To maintain a viable fossil fuel option, the FY 1991 Fossil Energy program has been shaped by five major factors:

1) Reducing the release of pollutants while simultaneously retaining, or enhancing, economic competitiveness.

There is no reason why the nation cannot call on its technological prowess to achieve both clean air and economic growth. The President's July 21, 1989, Clean Air Act proposal, if approved by Congress, can be the most far-reaching environmental step taken by any industrialized nation in the last 20 years. Of particular relevance to the Fossil Energy program are provisions:

- to control through market based solutions, emissions of pollutants known to cause acid rain;
- to regulate hazardous air emissions from stationary sources; and
- to establish programs for the use of clean fuels in vehicles.

Many of the technologies being demonstrated in the Clean Coal Technology Program or being developed in the Fossil Energy R&D program can help achieve the equal goals of a better environment and a healthy economy. Some of the advanced concepts could play a role in meeting the compliance deadlines established in the President's proposal; others will become vitally important after the deadlines by allowing sustained economic growth within the emission caps envisioned by the President's bill.

In light of this, the FY 1991 budget proposal places even greater emphasis on improving environmental performance of technologies by:

a) addressing global warming concerns, particularly through increased emphasis on development of high efficiency coal utilization systems;

b) pursuing a development schedule responsive to proposed Clean Air Act changes for technologies that can reduce acid rain pollutants or provide clean alternate fuels;

c) initiating development of pollution control technologies capable of achieving very high percentages of emission reductions anticipated for new plants by the proposed Clean Air Act changes, and

d) continuing the DOE/industry Clean Coal Technology joint effort to demonstrate innovative emission controls and power generating technologies that have near-term benefits.

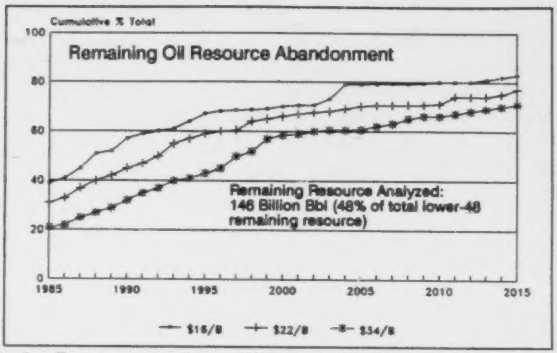
2) Slowing the decline in domestic oil production and countering the rise in imported oil levels.

U.S. oil imports are growing rapidly since lower oil prices have reduced domestic exploration and production. Domestic oil production in 1989 was at its lowest point in 25 years. The Energy Information Administration's 1989 Annual Energy Outlook shows gross oil imports (crude and petroleum products) rising from 47% of domestic consumption in

1987 to 53% in 1990 and to 66% by the year 2000 (in the "base case").

Particularly alarming is the loss of access to existing oil resources brought about by the accelerating pace of oil field abandonments.

In January 1990, the Department issued a study showing that as much as 40% of the nation's oil resource has already been abandoned—up from 30% in 1980—and if oil prices remain at recent levels (although this is not expected), the figure could rise to 70% shortly after the year 2000. As the chart shows, even if oil prices were to rise to $34 per barrel, the study predicts that companies will lose economic access to more than 60% of the remaining domestic oil resource, outside of Alaska, by the turn of the century. (It should be noted that Alaska accounts for 25% of U.S. production and while it currently does not have an abandonment problem, production from currently producing fields is declining.)



In light of this, the Department has proposed a major restructuring of its oil and gas research programs, with a greater near-term focus on keeping those wells in production that have a high potential for abandonment until longer-range, more effective recovery technology can be developed. This represents a shift in previous government research policies which emphasized longer-term, more basic research. The FY 1991 proposed oil and gas program continues the transition to this new program emphasis by including:

a) program priorities based on resource volumes, risk of resource abandonment and resource-specific barriers to recovery;

b) a major new effort to work jointly with industry-university-state consortia to develop a better understanding of reservoir geoscience and assist industry in prolonging the life of high potential oil fields that risk near-term abandonment;

c) a more aggressive technology transfer program to apprise operators of techniques that can keep economically marginal fields in operation; and

d) a new research effort into understanding and managing the environmental impacts of oil and gas extraction processes.

3) Encouraging interfuel and intrafuel competition.

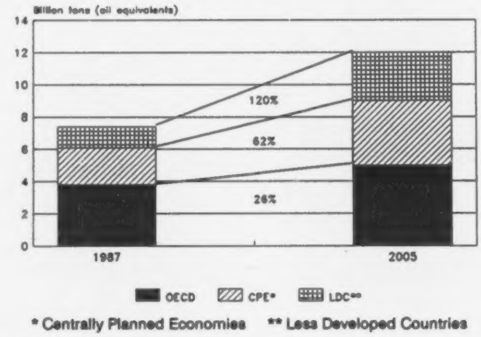
While this Administration continues to rely on free market forces to determine fuel choices, it is also helping to ensure a "level playing field" by elimating non-technical constrains on demand (e.g., non-productive regulations) and fostering development of technologies that can reduce costs, increase confidence in the availability of domestic resources, and offer new end-use options that can encourage competition among fuels. DOE's Fossil Energy program also promotes the development of interfuel competition and markets for U.S. natural gas and electricity through its regulation of natural gas and electricity imports and exports. These programs assure the availability of gas supplies to supplement domestic production. In some areas, they represent the majority of gas available to the market, since domestic production cannot be readily delivered to these areas. These supplies promote interfuel competition and boost consumer confidence in the reliability of natural gas.

Fossil Energy's regulation of electric import and export functions plays much the same role as that of gas. In addition, it adds to the reliability of the nation's electrical system by increasing its integration into the entire North American grid and thus providing an extra degree of stability that lessens the chance of blackouts.

4) Helping reduce the U.S. trade deficit by encouraging and assisting U.S. industry in identifying global markets and developing effective international marketing strategies.

U.S. owned advanced technologies will become increasingly important to a world being shaped by heightened environmental and economic priorities. The International Energy Agency recently forecast that in the year 2005 the world will be using almost 50% more energy than today – and about 90% of that energy will still come from fossil fuels. With the economic and social changes occurring in eastern Europe and the accelerating industrialization of many developing nations, the need for advanced technologies will become even more important. High efficiency clean coal technologies, for example, may be particularly important in protecting the earth's climate while continuing to allow the use of abundant coal supplies.

World Primary Energy Requirements



* Centrally Planned Economies ** Less Developed Countries

5) Increasing the benefits of R&D funds through cooperation with States and other countries

In his budget message, the President noted that "Considerable evidence exists that further increases in national R&D investment will enhance our productivity and brighten our future...In numerous instances States and localities are moving on their own, with their own funds to try new and innovative approaches to problem solving. This blossoming of State and local initiative is welcome." These comments provide support for FE's initiative to enter into competitive cooperative activities with States consistent with our mission.

Cost-shared cooperation promotes leveraging of Federal, state and industrial funding to achieve national energy and environmental goals, and is also an important tool for enhancing technology transfer to the private sector.

International cooperative activities can also play a beneficial role in leveraging FE R&D funds and ensuring that the U.S. remains in a technology leadership role. Collaborative international projects also promote U.S. presence in international markets which can facilitate future commercial technology sales.

The Clean Coal Technology Program

The Clean Coal Technology Program is a $5 billion, government-industry effort to demonstrate a variety of advanced, more efficient and environmentally responsive coal utilization technologies. These technologies will reduce or eliminate the economic and environmental impediments that limit the full use of coal. A series of "showcase" facilities are being constructed and operated across the country to demonstrate these improvements over conventional coal technology.

Technologies include new concepts for retrofitting improved pollution control equipment onto existing coal-burning power plants, new systems for repowering or replacing older electric generating facilities with advanced, high-efficiency clean power technology, and innovative approaches for producing clean-burning, coal-based fuel forms that can substitute for higher-value premium fuels.

The program requires at least 50 percent cost-sharing from industry and provides for recoupment of public investments from major commercial successes. To date, 38 projects are underway or in negotiation from the first three rounds of competition.

Prior Clean Coal Technology Funding Profile
($ in millions)

	1986	1987	1988	1989	1990	1991	1992
Round #1	$100	$150	$150				
Round #2			$ 50	$525			
Round #3					$575		
Round #4						$600	
Round #5							$600
	$100	$150	$200	$190	$710	$800	$600

← Special Envoys' Program →

Proposed Clean Coal Technology Funding Profile
($ in millions)

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Round #1	$100	$150	$150						
Round #2*			$ 50	$190	$135	$200			
Round #3*					$419	$156			
Round #4						$100	$250	$250	
Round #5							$150	$225	$225
	$100	$150	$200	$190	$554	$456	$400	$475	$225

* Rounds #2 and #3 funding stretchouts were directed by Congress in FY89 and FY90

← Special Envoys' Program →

The industrial cost-sharing for these projects has exceeded 60 percent. The Department had planned to issue its Round #4 solicitation on June 1 but has postponed the competition in accordance with Congressional direction in Public Law 101-302.

As the chart on the previous page shows, the budget request proposes to spread funding for the remaining two rounds of Clean Coal Technology competition over several years rather than compressing the budgetary requirements in fiscal years 1991 and 1992. This action will *not* affect the pace of the program. It will *not* result in any fewer projects selected. In fact, it is consistent with previous Congressional funding patterns (which allocated the Administration's FY 1990 request for $575 million for Round #3 over two years and previously has allocated the FY 1989 Round #2 request for $525 million over three years.)

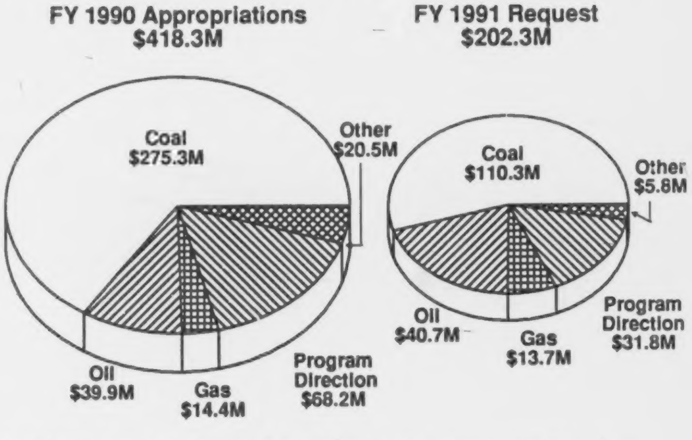
Selected clean coal technology projects, due to their multi-year duration and cost-sharing nature, receive funding typically over three to six years as design, construction and operation progresses. Consequently, the proposed new funding profile will not impact the program.

The Fossil Energy R&D Program

In contrast to the Clean Coal Technology Demonstration Program, the Fossil Energy R&D Program is oriented toward the initial stages of the development process -- i.e., the basic and applied research stages through the early stages of process engineering. The budget request for these activities is $202.3 million.

In carrying out this program, the Office of Fossil Energy, either through its headquarters or field centers, administers more than 500 individual research contracts, most carried out by industrial organizations or academic researchers. Within the FY 1991 budget proposal, priority has been given to programs and projects for which there is significant industry participation, either as a project participant or in many cases, as a project financial co-sponsor. In-house research, conducted principally at the Morgantown and Pittsburgh Energy Technology Centers as supporting research for the contract R&D projects, has been scaled back.

The FY 1991 budget also reflects a better balance between funding for coal and oil/gas research, as shown by the charts to the right. Given the near-term urgency of



In the FY 1991 request, Oil and Gas R&D comprise a larger funding share.

slowing the pace of oil field abandonments and increasing domestic oil production, the Department has earmarked 33 percent of its proposed FY 1991 research program budget (excluding Program Direction, Plant & Capital Equipment, and other non-research activities) for oil and gas related research, compared to only 17 percent in the FY 1990 appropriation.

FY 1991 Fossil R&D Budget Request – Summary Chart

Coal

Activity	Request
Control Technology & Coal Preparation	$33.5M
Advanced Research & Technology Development	26.5M
Coal Liquefaction	10.6M
Combustion Systems	17.6M
Fuel Cells	7.1M
Heat Engines	6.0M
Underground Coal Gasification	0.5M
Magnetohydrodynamics	0.0M
Surface Coal Gasification	8.5M
Total	$110.3M

Oil and Gas

Activity	Request
Advanced Extraction & Process Technology	$12.9M
Enhanced Oil Recovery	27.1M
Oil Shale	0.7M
Unconventional Gas Recovery	13.7M
Total	$54.4M

Other

Activity	Request
Fuels Programs	$ 2.7M
Environmental Restoration	0.7M
Program Direction	31.8M
Plant & Capital Equipment	2.4M

Coal

The FY 1991 budget request for coal research and development is $110.3 million. Within this budget request, priority has been given to technologies that can reduce the release of air pollutants, including sulfur dioxide, nitrogen oxide and particulates, in addition to carbon dioxide, one of the "greenhouse gases." Included in this priority are projects in *control technology and coal preparation, advanced research and technology development, combustion systems, fuel cells,* and *surface coal gasification.*

High efficiency concepts in *coal gasification, atmospheric* and *pressurized fluidized bed combustion, fuel cells* and *heat engines* are intended to provide options that can reduce the release of carbon dioxide.

Priority has also been given to technologies that potentially can open up new markets for coal and coal products. For example, programs to develop new *atmospheric fluidized bed combustors* and *alternative fuels* are directed at restoring the clean-burning coal option in light industrial, commercial and residential sectors. Programs geared to the transportation sector are found within the *coal liquefaction, surface coal gasification* and *heat engine* programs.

Control Technology and Coal Preparation

	FY90 Request	FY90 Approps	FY91 Request	% Change
Advanced Research	$ 1.9	$ 2.1	$ 1.7	-23.8%
Coal Preparation	11.3	19.9	12.2	-38.7%
Flue Gas Cleanup	11.4	16.8	8.6	-48.8%
Gas Stream Cleanup	4.6	16.7	8.5	-49.1%
Waste Management	3.1	2.1	2.6	+23.8%
Total	$32.3	$57.6	$33.5	-41.8%

Numbers may not add due to rounding

Advanced Research, generic and fundamental in nature, is conducted on processes used to separate constituents such as sulfur and nitrogen oxides in coal fuel streams before, during and after combustion.

Coal Preparation is directed toward the development of advanced coal cleaning technologies that will reduce the ash and sulfur content of U.S. coal so that the product can be formulated into a high quality fuel that could replace oil and/or gas and reduce environmental emissions of acid rain precursors from coal-fired power plants in both new and retrofit applications. Research is conducted in three broad areas: (1) physical treatment and cleaning; (2) chemical/biological pretreatment and cleaning; and (3) ancillary operations.

Flue Gas Cleanup addresses the removal of polluting contaminants from fossil fuel fired systems to meet current and projected environmental standards that inhibit the utilization of fossil fuels. Efforts focus on processes for the combined removal of NOx, SOx; control of SO_2 emissions from utilities; NOx control; emissions control from small scale boilers; and fine particulate control technology.

Gas Stream Cleanup develops technologies for removal of contaminants from gasifier and combustor process streams prior to application in coal utilization systems. Both hardware and environmental protection are key concerns. Applications include PFB combustors, integrated gasifier combined cycle gas turbines, and direct coal-fired turbines.

Waste Management focuses primarily on waste sampling and characterization from coal preparation and emerging technology wastes.

	FY 1991 Request (in millions)
Advanced Research	
• Continue fundamental research on processes used to separate constituents in coal-based fuel streams before, during and after combustion. (FY 1990 - $2.1M)	$ 1.7
Coal Preparation	
• Continue laboratory and bench-scale investigations of microbial concepts for pyrite and organic sulfur removal. Continue supporting research in ancillary operations for all ranks of coal and support studies. Initiate bench scale investigations of advanced chemical techniques for producing clean coal products capable of	9.6

	FY 1991 Request (in millions)
displacing oil and gas. Continue research on selected technologies for controlling emissions from pre-NSPS utility boilers (CCRI) to achieve the planned 1992 completion schedule. (FY 1990 - $9.8M)	
• Continue in-house research at bench scale to investigate advanced physical and chemical coal cleaning concepts. Continue organic sulfur chemistry. Maintain a data base, characterize feed coal and cleaned coal products. Continue program management support. (FY 1990 - $2.9M)	$ 2.6
Flue Gas Cleanup	
• Continue research for TUNG scrubbing process. Participate in EPRI program of emissions control for electric power generating stations burning high-sulfur coals. Continue in-house research in spray dryer and in-duct technology development. Continue systems integration studies for low cost duct injection for moderate and high sulfur coals. (FY 1990 - $7.1M)	5.0
• Continue research on advanced NOx/SOx chemistry, processes, system modeling, and by-product recovery. Conduct data base support and technical and economic evaluation of processes. (FY 1990 - $2.4M)	1.0
• Continue advanced research on reburning, catalytic, and post combustion control concepts. Continue advanced concept development at larger scale. (FY 1990 - $2.5M)	1.1
• Continue development of advanced separation technology for SOx/NOx control. (FY 1990 - $0.8M)	0.2
• Continue larger scale tests of fine particulate control technology. Complete FY 1989 contract on enhanced mass transfer effect on sorbent utilization. Continue research on emissions control from small scale boilers. Initiate development of CO2 control technology. Continue program management support. (FY 1990 - $1.1M)	1.2
Gas Stream Cleanup	
• For *Pressurized Fluidized-Bed Combustion*, assess feasibility of particle control and conduct follow-on research on barrier technical issues for particle control. (FY 1990 - $0.4M)	0.8
• For *Integrated Gasification Combined Cycle*, continue development of novel and enhanced sulfur sorbents. Continue novel fluidized bed cleanup system construction at the gasifier test facility. Continue design of joint project with industry for a particulate control test facility. (FY 1990 - $7.9M)	3.8
• For *Direct Coal-Fired Turbines*, continue development of acoustic enhanced combined sulfur/particulate removal. Carryout testing of cleanup equipment for METC combustor. Carryout granular bed	2.4

	FY 1991 Request (In millions)
filter tests and begin long term tests of selected concepts. (FY 1990 - $2.3M)	
• Continue membrane development. Continue development and testing of materials for ceramic candle and cross-flow filters. Conduct follow-on testing of novel particle control concepts. Fund program management support. (FY 1990 - $2.2M)	1.5
Waste Management	
• Perform characterization of low rank coal waste and waste based liner materials development. (FY 1990 - $0M)	0.2
• Continue multi-site field monitoring of disposed wastes; characterization of wastes; waste-related data base maintenance; and program management support. (FY 1990 - $1.2M)	2.4

Advanced Research and Technology Development

The Advanced Research and Technology Development (AR&TD) Program's overall focus is on removing the inherent scientific and engineering barriers in generic technical areas that may hinder the development of all fossil energy technologies.

	FY90 Request	FY90 Approps	FY91 Request	% Change
Coal Utilization Science	$ 3.5	$ 4.1	$ 3.3	-19.5%
Materials and Components	6.4	8.9	7.4	-16.9%
Technology Crosscut	11.8	7.7	10.4	+35.0%
University/National Lab Coal Research	3.8	5.7	5.4	-5.3%
Total	$25.5	$26.4	$26.5	+0.4%

The *coal science* program focuses on fundamental research which will lead to coal utilization systems that offer substantial improvements in efficiency, reliability and environmental performance.

The *materials and components* program includes generic studies of materials, solid transport, and novel concepts to significantly improve the performance and cost of existing fossil systems or enable the development of new systems and enhanced capabilities.

The *technology crosscut* program undertakes management and scientific studies and research relating to several crosscutting areas relating to fossil fuel technologies.

The *University/National Laboratory Coal Research program* conducts basic research on coal science, reaction chemistry, advanced process concepts, engineering fundamentals, thermodynamics, environmental sciences and high temperature phenomena.

	FY 1991 Request (In millions)
Coal Utilization Science	
• Continue fundamental research on the properties of constituents and the nature of reactions in coal utilization processes. Investiga-	$3.3

	FY 1991 Request (in millions)
tions are made of the formation, transformation and characterization of fuel and combustion product species; coal devolatilization, pyrolysis and volatile and char oxidation; and radiant heat transfer. (FY 1990 - $4.1M)	
Materials and Components	
• *Components:* Continue activities to develop novel components for advanced coal conversion technologies. Continue fundamental research on solid transport to include research on the Granular Flow Advanced Research Objective (GFARO) and exploratory research on multiphase flow. (FY 1990 - $2.5M)	1.3
• *Materials:* Continue research on structural ceramic composites, advanced austenitic alloys, ceramic filters, iron aluminides, coatings and claddings, ceramic membranes, ceramic catalyst supports, mechanisms of erosion and corrosion, solid state electrolyte materials, technology transfer and new ceramic materials processes. (FY 1990 - $6.4M)	6.1
Technology Crosscut	
• *Environmental Activities:* Continue analyses of issues associated with air and water quality, solid waste disposal, and toxic substances. Continue support of occupational health, quality assurance, and safety compliances services. (FY 1990 - $2.4M)	2.2
• *Technical & Economic Analyses:* Continue studies supporting FE multi-year planning and program formulation; conduct contract studies that crosscut a number of FE programs, including strategic benefits of new fossil fuel technology; provide technical and economic analytical support. (FY 1990 - $1.8M)	2.1
• *International Program Support:* Continue to conduct analyses, studies and technical evaluations of ongoing and planned bilateral and multilateral activities. Fund selected activities of the International Energy Agency. (FY 1990 - $0.7M)	1.0
• *Coal Technology Export:* Provide support for coal and coal technology export opportunities and initiatives. (FY1990 - $0.2M)	2.0
• *Instrumentation and Diagnostics:* Continue studies to measure acoustic parameters of fluids in multiphase flow, and research on laser-based chemical species analysis, particle species and size determinations. Continue sensor development for the harsh environments of coal conversion processes. Increase study of "expert" instrumentation system applications to coal utilization. Continue coordinating activities for all Fossil Energy instrument-related projects. Conduct research on an instrument to measure	1.7

FY 1991 Request (in millions)

the opacity of gas downstream of a barrier filter used to control erosion of turbine components. (FY 1990 - $1.5M)

- *Bioprocessing of Coal:* Expand research on coal bioprocessing, including work on: identification of more effective microbes and enzyme systems for bioconversion of coal, bioprocess engineering and related molecular genetics, and evaluation of thermophiles (i.e., organisms that function between 45 and 100 degrees C) for removal of sulfur, nitrogen and ash from coal. (FY 1990 - $1.0M) 1.4

University/National Laboratory Coal Research

- Support approximately 26 new grants at U.S. colleges and universities for basic research on coal science, coal surface science, reaction chemistry, advanced process concepts, engineering fundamentals and thermodynamics, environmental sciences and high temperature phenomena. Support 3-5 competitively determined research grants at Historically Black Colleges and Universities (HBCUs). (FY 1990 - $5.7M) 5.4

Coal Liquefaction

	FY90 Request	FY90 Approps	FY91 Request	% Change
Advanced Research	$ 3.1	$ 6.6	$ 2.9	-56.1%
Direct Liquefaction	2.9	17.7	4.5	-74.6%
Indirect Liquefaction	2.7	8.5	2.4	-71.8%
Support Studies/ Engineering Eval.	1.0	1.7	0.8	-52.9%
Total	$ 9.7	$34.5	$10.6	-69.3%

This program is developing advanced technology to produce synthetic liquid fuels from coal. The focus is on two approaches: *direct liquefaction* and *indirect liquefaction*.

The major funding reductions in this budget category are associated with the successful completion of tests at two process development units: the Wilsonville, AL, direct liquefaction facility, where tests of advanced integrated two-stage liquefaction have shown the potential for reducing the costs of coal liquids to the equivalent of $35 per barrel (from an estimated cost of more than $70 per barrel in the late-1970s); and the LaPorte, TX, liquid phase methanol synthesis development unit, where successful test runs have provided the basis for scale up of the process at the Great Plains Coal Gasification Plant under a cost-shared Clean Coal Technology project. Funding has also been elminated for generic bench scale activities at the Pittsburgh Energy Technology Center.

FY 1991 Request (in millions)

Advanced Research

- Continue research on: novel catalytic, biological and other approaches to coal liquefaction; improving the understanding of li- $2.9

FY 1991 Request (in millions)

quefaction processes; and, on novel catalytic approaches to coal liquefaction. Continue to fund technical and program management support. (FY 1990 - $6.6M)

Direct Liquefaction 4.5

- Continue PETC in-house research and laboratory research in co-processing, staged catalytic liquefaction and advanced process concepts. (FY 1990 - $17.7M)

Indirect Liquefaction 2.4

- Continue laboratory research at PETC. Continue laboratory research with industry and universities on oxygenate fuel process concepts. Continue novel catalyst research. (FY 1990 - $8.5M)

Support Studies/Engineering Evaluations 0.8

- Maintain process stream characterization research for advanced coal liquefaction and co-processing processes. Continue novel catalyst development and process studies at Sandia National Lab. (FY 1990 - $1.7M)

Combustion Systems

	FY90 Request	FY90 Approps	FY91 Request	% Change
Advanced Research	$ 1.2	$ 2.4	$ 2.2	-8.3%
Atmospheric Fluidized Bed Combustion	1.7	3.0	1.2	-60.0%
Pressurized Fluidized Bed Combustion	6.6	12.6	7.5	-40.5%
Advanced Combustion	2.6	5.5	3.7	-32.7%
Alternative Fuels Utilization	3.7	9.7	3.0	-69.1%
Total	$15.8	$33.2	$17.6	-47.0%

The Department of Energy has developed a program to increase the contribution and application of the nation's coal resources through the development of acceptable combustion systems and fossil-derived fuels for the marketplace.

First-generation *atmospheric fluidized bed combustion technology* is considered commercial for large industrial boiler applications (200,000 lb/hr steam and greater). Therefore, the Fossil Energy R&D program is aimed at extending the applicability of this technology to light industrial, commercial/institutional and possibly, residential sectors.

Similar target sectors are also being pursued in the *Advanced Combustion Technology Program*. The slagging combustors available in the near-term lend themselves most economically to the heavy industrial and utility markets; the Fossil Energy program is improving the industrial/utility concepts and extending the technology into the light industrial, commercial and residential markets.

Pressurized fluidized bed combustion is intended primarily as a utility power generating option. The first commercial-scale units are being installed in the U.S. in the Clean Coal Technology Program; thus, the Fossil Energy R&D program is concentrating on "second-generation" pressurized fluidized bed concepts.

Alternative fuels include raw or beneficiated coal, either pulverized or ultrafine; other solid coal-based fuels, either dry or in slurry form; and chars and liquids from coal conversion and stabilization processes.

	FY 1991 Request (in millions)
Advanced Research	
• Continue generic studies to examine the fundamental aspects of combustion mechanisms, engine combustion design, corrosive behavior and deposition of combustion products. (FY 1990 - $2.4M)	$2.2
Atmospheric Fluidized Bed Combustion	
• Continue to conduct in-house experimental and analytical erosion studies and AFBC development efforts. (FY 1990 - $0.5M)	0.4
• Continue proof-of-concept testing within the Advanced Concepts Program. (FY 1990 - $0.5M)	0.4
• Continue development of subsystem integration technology within the Special Applications Program. (FY 1990 - $1.5M)	0.3
• Continue low rank coal studies at UNDEERC. (FY 1990 - $0.1M)	0.1
Pressurized Fluidized Bed Combustion	
• Continue research efforts at METC on PFB dynamics, systems analysis and combustion characterization. (FY 1990 - $1.1M)	0.9
• Continue Advanced Concepts Phase III integrated subsystem tests at 5MWe pilot plant scale. (FY 1990 - $4.3M)	5.1
• Initiate construction of Hot Gas Clean-up Filter Test Facility at TIDD PFB Demo Plant. (FY 1990 - $5.9M)	1.4
• Fund technical and program management support. (FY 1990 - $0.1M)	0.1
Advanced Combustion Technology	
• Continue development of the most promising advanced combustion systems for industrial, utility, commercial and residential applications. (FY 1990 - $3.6M)	1.6
• Continue in-house activities on combustion enhancement and pollution suppression research including data base development for technology transfer to the private sector. Continue to provide technical and program management support. (FY 1990 - $1.0M)	1.1
• Continue advanced high efficiency cycles for CO_2 reduction. (FY 1990 - $1.0M)	1.0

	FY 1991 Request (in millions)
Alternative Fuels Utilization	
• Continue fuel characterization and boiler tests of beneficiated coal-leased fuels. Continue transport, handling and storage studies, and combustion characterization of beneficiated coal based fuels. Continue project management support. Assess and test deeply beneficiated coals for retrofitting large pre-NSPS coal-fired boilers for acid rain control. Provide technical and program management support. (FY 1990 - $5.5M)	$3.0

Fuel Cells

	FY90 Request	FY90 Approps	FY91 Request	% Change
Advanced Research	$ 1.0	$ 1.4	$ 0.4	-71.4%
Phosphoric Acid Sys.	0.0	8.3	0.0	-100.0%
Molten Carbonate Sys.	3.4	16.8	5.7	-66.1%
Advanced Concepts	2.1	11.5	1.0	-91.3%
Total	$ 6.5	$38.0	$ 7.1	-81.3%

The objectives of the Fuel Cells program are to support technology base development of fuel cell systems and to provide technology that improves U.S. international competitiveness by generating export sales for technology/products.

Advanced research, fundamental and generic in nature, is conducted to better understand the basis of the underlying processes involved in fuel cell operation and to explore novel concepts and advanced materials.

Phosphoric acid systems have reached a prototype commercial status. The IFC development effort is fully funded through its scheduled 1992 completion date. DOE believes that any further technology development should be the responsibility of the private sector.

The technical feasibility of *molten carbonate fuel cells* operating at approximately 60 percent electrical conversion efficiency (natural gas to busbar) has been forecast by single cell testing. The complexity and associated capital costs of advanced fuel cell systems are projected to be less than those for first generation phosphoric acid fuel cell systems.

The *solid oxide fuel cell* is an advanced, high temperature solid state fuel cell that offers promise in electric utility and in cogeneration applications in industrial and commercial sectors.

	FY1991 Request (in millions)
Advanced Research	
• Continue generic research in molten carbonate fuel cell electrochemistry. (FY 1990 - $1.4M)	$0.4
Molten Carbonate Systems	
• Continue two cost-shared MCFC system/stack contracts selected under the FY 1990 competitive action. (FY 1990 - $16.5M)	5.6
• Continue development of alternate anode materials, and program management support. (FY 1990 - $0.3M)	0.1

Advanced Concepts

	FY 1991 Request (in millions)
• Continue cost-shared development of tubular solid oxide fuel cell (SOFC) technology for coal-fueled applications. (FY 1990 - $8.9M)	0.9
• Continue gasification/SOFC systems analysis and materials development. Continue program management support. (FY 1990 - $2.6M)	0.1

Heat Engines

	FY90 Request	FY90 Approps	FY91 Request	% Change
Gas Turbines	$ 6.5	$10.4	$ 3.0	-71.2%
Diesel Engines	2.4	10.5	3.0	-71.4%
Total	$ 8.9	$20.9	$ 6.0	-71.3%

The principal goals of this program are to ensure the strategic security of liquid and gas supplies and to provide technology and technology-based products that improve U.S. international competitiveness by generating export sales for technology/products. Successful development of coal-fueled heat engines could provide an alternative to oil-fueled systems in industrial cogeneration, locomotive, marine and utility applications.

The program focuses on overcoming the technical problems associated with combustion, corrosion, deposition, wear and particulate control when burning dry, slurried or gaseous fuels in turbines and diesels.

Gas Turbines

	FY1991 Request (in millions)
• Continue coal-fueled gas turbine integrated systems testing with one contractor instead of three in FY 1990 (FY 1990 - $7.7M)	$2.1
• Continue pressurized coal combustion testing, systems analyses, and program management support. (FY 1990 - $2.7M)	0.9

Diesel Engines

• Continue coal-fueled diesel engine integrated system development with one contractor instead of two; continue novel concept project. Continue combustion testing and systems analysis, low-rank coal activities, and program management support. (FY 1990 - $10.5M)	3.0

Underground Coal Gasification

This program supports the development of viable technology for in situ conversion of coal to a cleaner burning, easily transportable gaseous fuel. Program efforts are directed toward the definition of technical, operational, and environmental parameters sufficient to allow industry to make decisions concerning the commercial development of the technology.

	FY90 Request	FY90 Approps	FY91 Request	% Change
Technology Develop.	$ 0.2	$ 0.2	$ 0.3	+50.5%
Environmental and Advanced Research	0.2	0.6	0.2	-66.7%
Total	$ 0.4	$ 0.8	$ 0.5	-37.5%

	FY 1991 Request (in millions)
Gasification Technology Development	
• Continue cooperative research efforts with WRI (FY 1990 - $0.2M)	$0.3
Environmental and Advanced Research	
• Continue environmental compliance, restoration, and reclamation activities at historical UCG test sites as required by law, (FY 1990 - $0.6M)	0.2

Magnetohydrodynamics (MHD)

The current FY 1990 MHD program continues the proof-of-concept (POC) program which is based on the Department's June 1984 Coal-Fired MHD Preliminary Transition and Program Plan. Since FY 1986, the Congress has included specific private sector cost-sharing requirements for the POC program in its annual appropriations laws. This program will provide the design basis for the development of components and subsystems and is aimed at furnishing the technology base for integrated, long duration, POC testing. Long duration POC testing is needed for the advancement of the MHD technology to the retrofit demonstration stage which is a necessary pre-requisite for subsequent commercial application.

	FY90 Request	FY90 Approps	FY91 Request	% Change
Proof of Concept Topping Cycle	$ 0.0	$25.4	$ 0.0	-100.0%
Proof of Concept Bottoming Cycle	0.0	9.0	0.0	-100.0%
Proof of Concept Seed Regeneration	0.0	2.5	0.0	-100.0%
Systems Studies, Spt. Research, Concep. Des.	0.0	3.5	0.0	-100.0%
Total	$ 0.0	$ 40.4	$ 0.0	-100.0%

	FY 1991 Request (in millions)
• Since it is estimated that $92 million (in 1988 dollars) is needed to complete POC testing, the Department believes that the cost of continuing its MHD program is not affordable in light of current fiscal constraints and in light of the development of other high efficiency techniques. (FY 1990 - $40.4M)	$0.0

Surface Coal Gasification

This program is organized to foster the development of advanced gasifier systems for the production of: electric power, synthesis gas (for synthetic natural gas, indirect liquefaction and chemical feedstocks), and coproducts (production of solids, liquids, and gases).

	FY90 Request	FY90 Approps	FY91 Request	% Change
Advanced Research	$ 0.7	$ 2.6	$ 0.5	-80.8%
Systems for Power Production	1.2	6.3	3.7	-41.3%
Systems for Industrial Fuel Gas Production	0.8	0.9	0.0	-100.0%
Systems for Synthesis Gas Production	1.1	1.7	1.1	-35.3%
Systems for CoProducts Production	4.9	11.9	3.2	-73.1%
Total	$ 8.7	$23.4	$ 8.5	-63.7%

This activity also provides for basic and fundamental research related to surface coal gasification processes including studies of reaction mechanisms and chemistry.

	FY 1991 Request (in millions)
Advanced Research	
• Continue coal gasification system assessment and modeling effort, studies of ash and slag characteristics, and precursor properties of condensible hydrocarbons (FY 1990 - $1.0M)	$0.5
Systems for Power Production	
• Continue METC in-house sulfur kinetic studies, efforts on fixed-bed and fluidized bed gasifiers and technical and program management support. (FY 1990 - $2.1M)	1.8
• Expand test program to develop a data base needed for commercialization of the GE gasifier cleanup system. (FY 1990 - $1.2M)	0.5
• Continue development and testing of hot desulfurization in an entrained flow reactor system for an IGCC demonstration. (FY 1990 - $1.4M)	1.4
Systems for Industrial Fuel Gas Production	
• The Industrial Fuel Gas production program will be phased out in FY 1991 and related research continued in other Surface Coal Gasification programs. (FY 1990 - $0.9M)	0.0
Systems for Synthesis Gas Production	
• Conduct transportation fuels study. (FY 1990 - $0.0M)	0.2
• Develop hydrogen preparation concepts. (FY 1990 - $0.5M)	0.3

	FY 1991 Request (in millions)
• Continue systems analysis and model development efforts. Provide technical and program management support. (FY 1990 - $0.6M)	$0.6
Systems for Coproducts Production	
• Conduct mild gasification studies to establish a matrix of product yields and investigate product options for coal-based fuels from mild gasification. (FY 1990 - $9.1M)	0.8
• Upgrade mild gasification plant to 1 ton/hr capability. (FY 1990 - $1.0M)	1.0
• Initiate studies to improve mild gasification product. (FY 1990 - $0.0M)	0.2
• Continue fuel upgrading R&D (FY 1990 - $0.4M)	0.5
• Continue modeling analysis and system analysis. Provide technical and program management support. (FY 1990 - $0.3M)	0.7

Petroleum and Gas

Extraction technology strategies to increase domestic oil and gas supplies include programs in enhanced oil recovery, unconventional gas recovery, oil shale and advanced extraction and process technology. In contrast to prior years, the Petroleum and Gas R&D program in FY 1991 proposes a much nearer-term strategy focused on identifying and maintaining economic access to high potential, high risk oil reservoirs and the development of a more complete data base of both conventional and unconventional natural gas resources.

The program also includes a mid-term strategy that emphasizes the use of advanced technology to maximize recovery effectiveness from oil and gas reservoirs, and a long-term strategy that seeks to improve basic understanding of oil reservoirs and develop so-called "speculative" natural gas resources.

Advanced Extraction & Process Technology

The Advanced Extraction and Process Technology (AEPT) Program pursues new concepts to achieve major increases in efficiency and cost reduction of recovery and upgrading techniques for oil, gas, and oil shale.

	FY90		FY91	%
	Request	Approps	Request	Change
Fundamental Geoscience and Extraction Research	$ 1.5	$ 2.8	$ 7.4	+164.3%
Supporting Technology and Environ. Research	3.1	0.8	4.2	+425.0%
University Geoscience Research	0.0	0.0	1.3	+100.0%
Total	$ 4.6	$ 3.6	$ 12.9	+258.3%

The goals of this research program are: to conduct fundamental research relevant to recovery and upgrading of oil, gas and oil shale; to pursue application of discoveries from unexplored new concepts which may achieve major increases in the recovery and upgrading of oil, gas and oil shale resources.

The Fossil Energy Office in FY 1991 will initiate geotechnology research based on the Hydrocarbon Geoscience Research Strategy and the detailed Oil and Gas Implementation Plan jointly funded with consortia of states, industry, and universities. The program will be based on competitive procurement of appropriate performers for major parts of the implementation. It is anticipated that this initiative will more align oil and gas R&D with the nearer term needs of the nation, will obtain greater cost-sharing by the private sector, and will facilitate technology transfer to the private sector. The AEPT program will support this initiative through research to overcome barriers to recovery identified by the Enhanced Oil Recovery and Unconventional Gas programs. Associated tasks in the Advanced Extraction and Process Technology program include reservoir description R&D; extraction and engineering R&D; and environmental and related R&D and technology transfer.

	FY 1991 Request (in millions)
Fundamental Geoscience and Extraction Research	
• Continue existing research on geoscience and extraction technology and development of advanced instrumentation to measure reservoir characteristics and thermal fronts. Explore novel extraction and production methods for oil, gas, shale oil, and tar sands liquids; continue research to develop theory, instrumentation, and predictive models to determine reservoir heterogeneities and relate this information to the production and recovery of bypassed oil and gas. (FY 1990 - $2.8M)	$4.3
• Initiate cost shared funding of geotechnology research consortia with states, universities and private industry in supporting technology associated with the Geoscience Strategy and the Oil and Gas Implementation Plan. (FY 1990 - $0.0M)	3.0
• Fund technical and program management support. (FY 1990 - $0.03M)	0.1
Supporting Technology and Environmental Research	
• Increase the program of fundamental studies including crosscutting research in petroleum chemistry focusing on structural characterization and determination of a structure-property relation of heavy crude, intermediate product stream, product, and byproduct, coprocessing, gas processing, and biotechnology. Fund technical and program management support. (FY 1990 - $1.0M)	4.2

University Geoscience Research

	FY 1991 Request (in millions)
• Continue funding third year PRDA program of university-based, fundamental research to advance oil and gas extraction. Fund technical and program management support. (FY 1990 - $0M) *Note: This item was funded in Fundamental Geoscience and Extraction Research in FY 1990.*	$1.3

Enhanced Oil Recovery

	FY90 Request	FY90 Approps	FY91 Request	% Change
Light Oil	$14.2	$22.5	$22.5	0.0%
Heavy Oil	4.1	4.0	4.6	+15.0%
Tar Sands	0.0	0.9	0.0	-100.0%
Total	$18.3	$27.4	$27.1	-1.1%

Enhanced oil recovery (EOR) can help sustain domestic oil production in the critical period between now and the time when the nation will likely rely more extensively on synthetic and renewable fuels. The program is addressing the near-term problems of maintaining access to currently producing marginal fields and is targeting research on specific, high priority resource classes. It is also developing advanced techniques that can maximize recovery. In FY 1991, a regional/reservoir research program jointly funded with consortia of states, industry and universities will be initiated.

Light Oil

	FY 1991 Request (in millions)
• Continue research in light oil recovery techniques and conduct related planning, technical and analytical assessment, and program management support to classify and prioritize resource targets and research activities (FY 1990 - $4.4M)	$3.4
• Initiate a key regional/reservoir research program jointly funded with consortia of states, industry, and universities. (FY 1990 - $0M)	10.0
• Continue a geoscience effort and reservoir characterization and related fundamental studies addressing definition of reservoir structure and composition. (FY 1990 - $9.3M)	4.8
• Initiate a program to understand the environmental impacts associated with light oil recovery operations. (FY 1990 - $0M)	0.7
• Provide support for a MEOR conference and continue thermophilic bacteria recovery efforts. (FY 1990 - $2.7M)	0.3
• Continue the industry/state cooperative effort. Conduct a technology transfer program to include meetings, workshops and extension service offices. Continue the National Laboratory/industry	3.3

FY 1991 Request (In millions)

partnership program. (FY 1990 - $2.8M)

Heavy Oil $1.5

- Continue basic research in mobility control mechanisms and alkaline flooding. Initiate an alkaline flood test. (FY 1990 - $1.6M) 0.9
- Conduct a study to identify resource targets and conduct related planning and analytical assessment studies. Conduct a technology transfer program to include workshops, extension service offices, and a summer intern program. (FY 1990 - $0.5M) 0.4
- Continue fundamental research on reservoir and fluid properties (FY 1990 - $1.1M) 0.8
- Initiate an environmental impact program for heavy oil. (FY 1990 - $0M) 1.0
- Continue a geoscience characterization program, research in novel extraction approaches to presently deemed unrecoverable, heavy oil resources, and fundamental studies of reservoir characteristics and injection fluid interactions. Provide program support. (FY 1990 - $0.9M)

Oil Shale

	FY90 Request	FY90 Approps	FY91 Request	% Change
Technology Base	$ 1.0	$ 6.7	$ 0.7	-90.0%
Environmental Mitigation	0.7	2.3	0.0	-100.0%
Total	$ 1.7	$ 9.0	$ 0.7	-92.2%

Oil shale technology development involves the development of extraction and conversion processes designed to convert oil shale to various liquid fuels. The program focuses on basic research to systematically study the chemistry, kinetics, and emissions related to eastern and western shale processing. The FY 1991 program proposes to reduce funding for oil shale research in favor of more near-term, urgent priorities in the petroleum program. Basic research in oil shale properties is continued with engineering work on retorting and related process-related effort being postponed for the present time.

FY 1991 Request (In millions)

Oil Shale Technology Base

- Continue funding for WRI to perform characterization of reference shales. (FY 1990 - $6.7M) $ 0.7

Environmental Mitigation

- No activity. (FY 1990 - $2.3M) 0.0

Unconventional Gas Recovery

	FY90 Request	FY90 Approps	FY91 Request	% Change
Eastern Gas Shales	$ 0.3	$ 3.2	$ 2.7	-15.6%
Western Tight Sands	0.3	3.5	3.0	-14.3%
Environmental and Advanced Research	3.5	7.7	8.0	+3.9%
Total	$4.1	$14.4	$13.7	-4.9%

This program develops advanced technologies to extract natural gas from currently unrecoverable gas resources by reducing the uncertainty in the magnitude of the gas resources and the conditions under which they can be produced.

In FY 1991, the program will initiate jointly funded research with a consortia of states, industry and universities to develop a natural gas data system and a classification scheme for conventional gas reservoirs.

	FY1991 Request (in millions)
Eastern Gas Shales	
• Continue in-house support and update the predictive models associated with reservoir and stimulation performance; continue systems studies in support of production strategies; complete field tests for gas production in multiple strata; conduct fractured reservoir mapping studies; and complete horizontal drilling/production tests. (FY 1990 - $3.2M)	$2.7
Western Tight Gas Sands	
• Complete extrapolation of multi-well results to other areas of gas potential. Continue studies on developing concepts for the origin of natural fractures in tight sand basins. Complete stimulation of slant/horizontal well. (FY 1990 - $3.5M)	3.0
Environmental and Advanced Research	
Speculative Resources	
• Continue in-house geologic, geophysical and geochemical efforts to study deep source gas generation potential in subduction zones and associated sediments. (FY 1990 - $0.2M)	0.3
• Continue research on geological/geochemical studies on origin and mitigation of gas in deep sedimentary basins. (FY 1990 - $0.5M)	0.5
Conventional Resources	
• Establish and develop diagnostics for evaluating and characterizing natural and induced fractured gas reservoirs. (FY 1990 - $0)	1.5

	FY 1991 Request (in millions)
• Initiate development of a natural gas data system for both unconventional and conventional reservoirs. Initiate development of a gas classification system for conventional reservoirs based on depositional environments and recovery efficiencies. This research will be jointly funded with consortia of states, industries and universities. (FY 1990 - $0)	$4.0
• Initiate effort to improve economics of air-drilled horizontal wells through improvements in drilling and completion techniques. (FY 1990 - $0)	1.0
• Complete secondary gas recovery project. (FY 1990 - $3.0M)	0.7

Fossil Energy Environmental Restoration

In May 1983, the Pittsburgh and Midway Coal Mining Co. (P&M), the DOE contractor/operator of the Ft. Lewis Coal Liquefaction Pilot Plant (Tacoma, Washington), was notified by EPA that they were potentially liable along with hundreds of others for cleanup of the Western Processing Site. DOE, P&M and others agreed to pay the costs of cleaning up the site and a trust fund was established to receive and disburse payments.

Total site cleanup (Phase I/Surface and Phase II/Subsurface) was estimated to be a minimum of $40 million. Currently, cleanup is in Phase II and monitoring will not be complete until the year 2020.

In May 1988, the Laramie Project Office received a Notice of Violation from the Wyoming Department of Environmental Quality. As a result, DOE has agreed to assist in the cleanup of the groundwater contaminated by hydrocarbons at the Rock Springs Oil Shale retorting site. Cleanup of the Rock Springs site includes groundwater sampling and analysis, pumping and water treatment, well abandonment and reseeding.

As a result of the DOE environmental survey that was conducted in February, 1989; it was found that two FE Surface Coal Gasification research PDUs at the Rockwell International Site (Calif.) required cleanup of hazardous materials. Government owned property accountable under the contract is contaminated with hazardous materials including tars, heavy oils, and asbestos generated during the conduct of R&D at the Rockwell Site. Also discovered during clean-up was asbestos insulation on piping and a 150 foot underground contaminated line.

	FY 1991 Request (in millions)
• Continue to fund DOE share of Ft. Lewis trust fund Phase II cleanup of Western Superfund site. (FY 1990 - $1.0M)	$0.2
• Continue cleanup of the Rock Springs site using prior year funds. (FY 1990 - $0.0M)	0.0
• Fund cleanup of hazardous materials at the Rockwell International site. (FY 1990 - $0.0M)	0.5

Fuels Programs

	FY90 Request	FY90 Approps	FY91 Request	% Change
Fuels Programs	$2.7M	$2.7M	$2.7M	0%

The Office of Fuels Programs is responsible for regulating natural gas imports and exports, transmission facilities for electricity imports, electricity exports, and implementing the Powerplant and Industrial Fuel Use Act. The Office also develops trade policy for natural gas and electricity.

	FY 1991 Request (in millions)
- Provide funding for the regulation of natural gas imports and exports, electric import transmission facility certification, electricity export authorization, and implementation of the Powerplant and Industrial Fuel Use Act; and the development of natural gas and electricity trade policy (FY 1990 - $2.7M)	$2.7

Program Direction

	FY90 Request	FY90 Approps	FY91 Request	% Change
Headquarters Program Direction	$ 9.1	$ 16.2	$ 9.9	-38.9%
ETC Program Direction	16.5	51.8	21.6	-58.3%
Federal Inspector for the Alaskan Natural Gas Transportation System	0.2	0.3	0.3	0.0%
Total	$25.8	$68.3	$31.8	-53.4%

This activity provides funding for salaries, benefits and overhead expenses for the management of FE programs at Headquarters, the Energy Technology Centers, the Bartlesville Project Office, and the Metairie Site Office.

The Headquarters element has overall program responsibility which is accomplished through the development and implementation of policy, establishment of program objectives and by monitoring the performance of work conducted at the field offices.

The Bartlesville Project Office, Metairie Site Office and the Energy Technology Centers (ETCs) support day-to-day project management functions for assigned programmatic areas including performing such in-house research program activities as contract and National Laboratory monitoring, development and maintenance of project, budget and procurement plans, and other activities related to program and site support.

The Office of the Federal Inspector for the Alaskan Natural Gas Transportation System is responsible for coordinating all Federal activities pertaining to the construction and initial operation of the pipeline. The Office of the Federal Inspector also enforces federal laws and permits, and monitors activities that affect the system.

	FY 1991 Request (in millions)
Headquarters Program Direction	
• Provide funds for salaries and benefits of 123 FTEs at Headquarters. This staff implements and communicates policy to the ETCs, sets program objectives, develops program plans and evaluates alternative strategies; develops and defends budget requests; approves procurement plans, monitors work programs. (FY 1990 - $9.1M)	$8.7
• Fund travel in support of the activities stated above. Both domestic and international travel is conducted. (FY 1990 - $0.7M)	0.5
• Provide contractual services that are generic to the entire FE program. Included are items such as printing, computer services, technical support services, conferences, etc. (FY 1990 - $6.4M)	0.8
ETC Program Direction	
• Fund salaries and benefits of the ETC staff of 301 FTEs. Activities of the staff include contract and lab monitoring; development and maintenance of project, budget, and procurement plans, and other activities related to program and site support. (FY 1990 - $20.4M)	16.3
• Fund travel in support of the coordination of the above activities in the attainment of program goals, both on the domestic front and abroad. (FY 1990 - $1.0M)	1.1
• Fund facility operations, maintenance, finance and administrative contractors and other costs not appropriately chargeable to R&D projects, in support of this level of FTEs. (FY 1990 - $30.4M)	4.2
Federal Inspector for the Alaskan Natural Gas Transportation System	
• Fund administrative and support functions; continue to assess developments in U.S. and Canadian energy markets and maintain liaison with project sponsors, producers, other government agencies, State of Alaska and Canadian government. (FY 1990 - $0.2M)	0.3

Plant and Capital Equipment

	FY90		FY91	%
	Request	Approps	Request	Change
Capital Equipment	$ 0.0	$ 1.5	$ 1.3	-13.3%
Construction	1.9	10.5	1.1	-89.5%
Total	$ 1.9	$12.0	$ 2.4	-80.0%

Capital equipment is purchased to replace obsolete equipment so that the ETCs and the

National Laboratories analytical capabilities are constantly being upgraded. General plant projects are essential to the safe, efficient operation of the ETCs and construction is dedicated to a number of improvement, alterations and additions at each of the ETCs.

	FY 1991 Request (in millions)
Capital Equipment	
• Provide centralized funding for capital equipment needs at the ETCs, National Labs, and BPO. (FY 1990 - $0.5M)	$0.5
• Provide funding for additional computing capacity at Pittsburgh ETC to support new activities that include business and technical modeling, cost/price and financial analysis and tracking of contract deliverables. (FY 1990 - $1.0M)	0.7
Construction	
• Provide for General Plant Projects (GPP) at the ETCs and BPO. (FY 1990 - $1.8M)	0.5
• Continue construction of the program support facility at PETC. (FY 1990 - $3.0M)	0.7

Mr. **Boucher**. The chair thanks the gentleman for his testimony this morning.

The chair has several areas of inquiry, and let me begin with the Clean Coal Program, because you mentioned that, I think, in concluding your statement. It obviously is a very important next step in assisting new technologies in reaching the marketplace, but to my way of thinking it clearly receives a disproportionate share of funding when you take into account the amount that clean coal receives and the amount that basic coal research and development receives.

The basic coal research budget is designed to help commercialize a broad range of new coal technologies that are designed to do more than simply allow coal to burn more cleanly, to produce liquid fuels derived from coal, for example. That simultaneously would help the country achieve energy independence, and it would help utilize the Nation's most abundant energy resource, which is our supply of coal.

So I have a particular fondness for that basic coal research budget, and I really think that you undervalue those efforts with the kind of budget submittal that's been made today, and I think it's particularly undervalued when you compare it with the amount of money that we're spending on clean coal technologies.

So I would appreciate any comment that you have concerning that general set of concerns and why, in light of those concerns, the coal research budget submittal by DOE is, in fact, so low.

Mr. **Gentile**. Mr. Chairman, the Department assigns a very high priority to the overall Coal Program, and the Clean Coal Program is not directly impacting the R&D funding. The overall Coal Program has a full spectrum of R&D. It's both in the applied research, it moves into systems process and development, and it also moves into the demonstration with the clean coal technology, and we need that full spectrum of R&D to develop new concepts and eventually move them into the marketplace.

Taken together, we feel this demonstrates a major commitment to coal; however, in this fiscally constrained environment, we can't do everything, and hard choices have to be made. However, we have every confidence that we have represented within our Coal Program that full spectrum, and it demonstrates the Department's commitment to coal.

Mr. **Boucher**. Well, let me explore with you one specific area. I have in my Congressional district an R&D effort that is in part funded by the Department of Energy that is designed to produce a liquid fuel derived from coal through a mild gasification process. There are some other useful byproducts that are produced—there's a char that can be burned in the place of wood or other fuels for heating purposes as one of the byproducts.

That is receiving funding out of, I believe, the surface coal gasification item in your budget submittal, and I notice that even though we have a great potential for producing these liquid fuels that can expand coal into the transportation sector and again help us achieve energy independence, which I think we all would agree is a very worthwhile national target, that your recommendation for funding in that category is 64 percent less than was the appropriated level for this year.

Now, how do you reconcile that clear need, which I think we all would agree with, to produce liquid fuels derived from coal that can accomplish that set of purposes, with your funding recommendation of 64 percent less than the appropriated level for this year?

Mr. **Gentile.** Mr. Chairman, there is a series of projects going on around the country in coal liquids, and I'm familiar with the facility that you mentioned. I visited that facility, and I have visited several other facilities around the country—as recently as two days ago, a facility in North Dakota.

Basically, what we have here, we're not cutting out anything, we're stretching this out. We did undertake a study in liquids, that study was completed by the National Academy of Science's NRC, we are looking at that study in terms of how we're going to approach our planning for the next cycle and the next budget, and that study will definitely impact how we approach that budget.

We have not eliminated anything in this program, we're trying to stretch out the development, and given the amount of funds that we have available, it was important to be able to continue whatever we could, and that's what we've done here. We've tried to continue everything that we could without cutting anything out.

Mr. **Boucher.** Well, also, on the same topic, you mentioned a study which the Department has. Perhaps that study could provide some guidance to us in terms of the targets of our funding and the kinds of emphasis that we should place on particular projects, and if you could share that with the Subcommittee, I think we would find that useful.

Mr. **Gentile.** I think we have, Mr. Chairman. We'd be happy to supply that again. It is the liquids study done by the NRC. We will be sure to give that to you. (On file in committee offices.)

Mr. **Boucher.** All right. Well, we would appreciate that. On that same note, could you provide us with a general overview today of your ongoing research with liquefaction, where you stand with various projects and, generally, what an overview of your future plans in that area are?

Mr. **Gentile.** Well, in coal liquefaction, we're broken into several areas: advanced research, direct liquefaction, indirect liquefaction, and support studies in engineering. The total request for liquefaction in 1991 is $10.6 million.

The major reasons for the decreases are the completion of the work in Wilsonville. We're quite pleased with that work, actually. Direct liquefaction has brought fuels from coals down to about the $35 per barrel range. In the 1970s, that was at $70 per barrel.

We're also completing the work at La Port in indirect liquefaction. The other main reason for the reduction is some cutbacks in in-house research at Pittsburgh Energy Technology Center and some work by contractors. But the major efforts in 1991 are in direct liquefaction, the work continues on advanced catalytic concepts, and part of the Pittsburgh Energy Technology Center's next generation of effort is to bring coal liquids down to the $25 to $30 per barrel in 1988 dollars that we're striving for.

Indirect liquefaction, we have some small in-house research at PETC at Pittsburgh, and we're doing a new RFP in advanced Fischer-Tropsch catalysts.

Mr. **Boucher**. You mentioned the Wilsonville liquefaction pilot plant. The Department, I think, historically has done some testing at that facility. Two questions. First, are you continuing testing there, do you have plans for any in the future? And, secondly, are you recommending that any sums be provided by the Government for testing at that facility?

Mr. **Gentile**. No, we're not, Mr. Chairman. We're planning on closing down the Wilsonville facility early in fiscal year 1991.

Mr. **Boucher**. Do you believe that its useful work is complete?

Mr. **Gentile**. We believe that more work could be done. Again, Mr. Chairman, it's a matter of competing priorities. As I said, we were quite encouraged that we've gotten the liquid price down to about $35 per barrel, but given competing priorities, it's a little further out research, and we needed to concentrate on some things closer in.

Mr. **Boucher**. The goal of the testing at that facility is to try to make liquefaction cost competitive with other fuel sources. Is that correct?

Mr. **Gentile**. Yes, it is.

Mr. **Boucher**. Are you cost competitive today?

Mr. **Gentile**. No, we're not. We're worried about $35 per barrel.

Mr. **Boucher**. What is the market price for the product today? How far do you have to go to be cost competitive?

Mr. **Gentile**. The price that we're trying to get down to is the $25 to $30 per barrel, Mr. Chairman. I doubt, given the prices of oil as we've seen—I think this week West Texas was down at about $15.25—we're not going to be able to compete at that price. Our goal in our program is to compete at the $25 to $30 range. We feel that given the technology and the direction of technology, in five to seven years we might be able to get down in that range in 1988 dollars, but we're not going to be able to compete at the $15 range.

Mr. **Boucher**. Well, even at the high end of that range, you mentioned $30 as the high level at which you might be able to compete, you're still not there. Your work at Wilsonville has brought you, I believe you said, the $35 per barrel, but you're still not cost competitive. Why, then, in light of the very clear need to achieve a higher level of American energy independence, to rely less on foreign oil imports, to utilize more effectively our coal resources, given the fact that you're still not cost competitive and you lack at least $5 per barrel from getting there, are you planning to close the Wilsonville facility?

Mr. **Gentile**. Well, again, Mr. Chairman, it's strictly a situation of competing funds. Given the study that we've recently received on liquids, we'll probably be rethinking that in the next cycle. It was recommended by Congress that we take on that study, it was done, we have received it, and we will be looking in the next cycle toward that study for direction.

Mr. **Boucher**. Mention, if you would, the potential for other forms for the conversion of coal to a liquid fuel than direct liquefaction, and I'm making reference again to technology such as mild gasification that, through a process that's akin to the coking process, produces a liquid fuel that can be used for transportation.

Where does that kind of technology stand today in terms of cost competitiveness, what is the cost per barrel of producing that kind of fuel, given the current state of the technology, and what kind of trend do you see in terms of being able to make that truly cost competitive?

Mr. **Gentile**. I think that you may be referring to something similar to the oil shale extraction of liquids——

Mr. **Boucher**. Well, I'm referring to the mild gasification technology.

Mr. **Gentile**. I guess we're having trouble understanding the question, Mr. Chairman. You're talking about mild gasification.

Mr. **Boucher**. You are funding today one or more projects in mild gasification, one of the products of which is a liquid fuel derived from coal which can be used for transportation. It is another kind of liquid fuel derived from a process other than direct liquefaction.

My question very simply is, what is it costing per barrel, given the state of that technology today, to produce that liquid fuel? You said $35 per barrel for direct liquefaction. What's it costing to produce the fuel by this mild gasification process?

Mr. **Gentile**. The problem with the mild gasification is that the quality of the product isn't the same. It's at about $25 per barrel right now, but we're not talking the same quality product.

Mr. **Boucher**. Can it be used for transportation purposes?

Mr. **Gentile**. At this point, yes, it can be used, yes.

Mr. **Boucher**. You said $25 per barrel. Now, do you view that as being cost competitive in today's market?

Mr. **Gentile**. Probably not. Let me turn this question over to Jack Siegel, if I could, please.

Mr. **Boucher**. Sure.

I'm sorry, sir, your name is?

Mr. **Siegel**. Jack Siegel.

Mr. **Boucher**. Mr. Siegel, we'll be happy to hear from you.

Mr. **Siegel**. Yes, $25 per barrel at today's economics certainly is not competitive. As Mr. Gentile said, today's oil prices are closer to $15 per barrel, but our Energy Information Administration does project that by the year 2000 oil prices might be in the $25 to $30 per barrel range, so then the technology could be competitive.

Mr. **Boucher**. Well, there are two ways to make the technology competitive. One is obviously to wait until the price of oil goes up. Another way, and this is one I would commend to you, is to put some money into the technology now so that we can improve it and bring the price of the liquid fuel produced by the technology down.

Now, in view of the fact that this technology is closer to being cost competitive than is direct liquefaction, you're at $35 per barrel with direct liquefaction, this is being produced at $25 per barrel, you have said that it is of a quality sufficient for use in transportation today, why are you not directing a more substantial effort for trying to perfect that technology and make it truly cost competitive today, given its obvious greater promise?

Mr. **Siegel**. It doesn't necessarily have greater promise. It's a nearer term technology for producing liquids from coal than is direct or indirect liquefaction. We don't have any ideas for any additional ways of reducing the cost of mild gasification. We do for liquefaction.

Mr. Boucher. Well, let me interrupt you at that point. What do your researchers say, the companies that you're contracting with to produce the technology? Do they have some ideas for how the cost can be brought down?

Mr. Siegel. No, I don't think so. I think really where the program is heading right now is the scale-up of the technology to a scale to prove that, in fact, the technology can work technically, economically, and environmentally.

Mr. Boucher. So you're saying you basically know as much about the technology as you can learn, it's simply a matter now of producing the product at larger scale?

Mr. Siegel. That's right.

Mr. Boucher. And that's where your effort is currently focused?

Mr. Siegel. That's right. Now, with respect to liquefaction, that's not the case. With liquefaction we have further R&D improvements that we anticipate.

Mr. Boucher. Okay.

Mr. Gentile. There are four programs or projects that I would point out, Mr. Chairman, in mild gasification. One is the WRI-AMAX Rielly Stoker. The PDU was constructed in 1989, and it's testing subbituminous coal currently. At North Dakota, we have another demonstration unit nearly complete, and the shakedown is scheduled to start right about now.

In the Coal Tech Corporation, the design should be completed now, and construction is scheduled to be completed later on this year. In IGT Peabody, the evaluation is ongoing, and we hope to have some studies completed by August of 1990. And we have a clean coal project in Great Plains in North Dakota and coal shale. It's a round three coal mild gasification with shale oil and coal in Wyoming.

Mr. Boucher. All right. The chair appreciates those answers. I have one other question, and that is, could you give us some idea of what other countries are involved in liquefaction research today, and where do they stand in comparison with our efforts? Are we ahead or behind, and, if we're behind, what plans do you have to catch us up?

Mr. Gentile. Well, the traditional work has been done for many years in South Africa in direct liquefaction, of course, at SASOL. Other countries that are doing some work—there's a Japan-Australia joint venture doing direct work, they're doing about 150 tons per day, there's some work being done in Germany, Russia, and the U.K. The SASOL project has been going on for many, many years. We know that technology, and I don't think we're behind the curve at all at this point.

Mr. Boucher. With regard to any of those countries, is that correct?

Mr. Gentile. Yes, sir.

Mr. Boucher. Well, gentlemen, I appreciate those answers. The chair has a number of additional questions which we will submit in letter form to the Department, and the record will be held open pending receipt of your answer.

We are now in the middle of a recorded vote on the floor, and before recognizing the gentleman from Washington, the Committee will recess for that vote. We'll reconvene in 10 minutes.

[Recess.]

Mr. **Bruce** [assuming the chair]. Thank you, Mr. Gentile, for your testimony and I apologize for the break on the vote.

Are there questions of the panel?

Mr. Morrison.

Mr. **Morrison**. Thank you, Mr. Chairman.

Mr. Gentile, we certainly welcome you as the first time in front of this Subcommittee. We, of course, deem the efforts that you're involved in as vitally important. I don't have any of the facilities directly in my district, so I'd like to ask you perhaps more of a philosophical question as we see your program being modified rather significantly.

Just a word of background—we have seen the Department of Energy basically making the long term investment in research, the sorts of things that the commercial side of the House feels they can't afford to do, and then as that basic science is ready for application, there's a greater private enterprise involvement.

So most of the energy programs we deal with fit in that category. I find it rather interesting, then, that in the fossil fuel area you're considering making, you know, the leap to exactly the opposite, that is, the short term, applied, let's-get-some-oil-out-of-the-ground sort of effort, and I just wonder if you could share with the Subcommittee how these priorities have been determined and why the difference with other Department of Energy type programs?

Mr. **Gentile**. Congressman, the last 10 years has been a rather sobering experience in the fossil area. We've seen an increased interest in the fossil fuels, and we've seen some problems emerging. In the area of oil, for example, we see abandonment rates in our producing fields, we're getting about a third of the oil out of the ground right now, we're seeing wells being plugged, we're seeing fields being abandoned, we're seeing domestic production declining, we're seeing imports increasing.

Our whole purpose here in the Oil Program is to try to preclude that. How do we assure that we're going to have production coming out of our own fields? How do we ensure that we're going to develop some of that technology to access some of that bypassed oil?

In the coal area, we're seeing increased environmental concerns. It's been happening over the last 10 years. Our challenge there is to define ways of burning coal economically and environmentally soundly. We've seen a move from SO2 and NOX, and now we're moving toward the greenhouse gases.

So I guess what I'm saying is in the last 10 years we've problems emerging in the short run that have had to be dealt with so quickly that it has not been possible for us to concentrate only on long term and let the commercial sector respond to short term.

Mr. **Morrison**. I presume the competition position, because of prices worldwide, undercuts the ability of private enterprise to respond to these needs.

Mr. **Gentile**. Absolutely. If we see what's just happened in oil prices, when you've got lifting costs in the U.S. that are considerably more than they are in the Middle East for oil, for example, there's just no way that we can compete on the same basis.

We also see the same thing happening in coal, so the margins for the private sector aren't there to do the types of work they were doing before. The problem is being exacerbated, and it's just important for DOE to be in the middle of this so that we ensure that we use the energy resources that we have in this country in a way that's both efficient and environmentally sound.

Mr. MORRISON. I suppose there's also a certain presumption that Congress is going to build back in some of these programs that perhaps you have set to one side. Is that a leading question?

Mr. GENTILE. Well, that's not how the budget was developed, Congressman. The budget was developed to try to prioritize, given the limited resource, where we need to concentrate, and that's how we've done it.

Mr. MORRISON. I respect that. My guess is that also we'll see Congress building some of these back in whether, in fact, that's in your best view or not. My understanding is there will be a separate hearing on clean coal technology, but I did take to note certainly your comments that the clean air bill as it passed looks like it used our clean coal technology as a source of funding to help solve some other problems, and I just want to assure you and the Department that this Subcommittee, feeling some responsibility in that area, I'm confident is going to step in and do what's possible to make sure that the research program is not undercut.

I think that's absolutely vital with the volume of coal that we have and the role that it needs to play in our energy future.

Mr. GENTILE. Thank you, Congressman.

Mr. MORRISON. Thank you, Mr. Chairman.

Mr. BRUCE. The chair recognizes Mr. Smith of Texas for questions.

Mr. SMITH. Thank you, Mr. Chairman.

Mr. Gentile, let me add my welcome as well. I have a particular interest in the Oil Research Program, and I'd like to go back to that. First of all, would you give me an idea of the type of cooperation that you expect between the Department of Energy and private industry in regard to that program?

Mr. GENTILE. Well, Congressman, in putting the program together, we did a considerable amount of work, both with the private sector and with States and universities, we looked at several different reports, the Geoscience Institute, we did a report on EOR, we talked to State geologists. The process of putting the plans together, the geoscience and the oil and gas implementation plan, was a process of interaction with those entities.

As a result, we've had very good reaction. I was addressing the Interstate Oil Compact Monday and had a very positive reaction from the IOCC. We've had a very good reaction from the State geologists. We seem to have built some sort of a consensus document here that the private sector, the States, the universities feel we're on the right track when it comes to oil and gas.

Mr. SMITH. Actually, you've anticipated a couple of the questions that I had. One aspect of that program is the site selection aspect of it, and I understand that one of the factors that is going to be considered is the interest of the local industry and the local communities. What can they do to express support for the program? What can they do to show an interest that would make you more inclined to consider that particular location?

Mr. GENTILE. Well, Congressman, actually, the way that we're going to prioritize the reservoir classes will be based on the amount of potential oil that's still in place that could possibly be recovered and the highest risk of possibility of abandonment.

Mr. SMITH. So they need to gather data and information and present it to you?

Mr. GENTILE. Yes. We're in the process of looking at those reservoirs right now to see where the highest potential for additional recovery is and where the highest potential for risk of abandonment is. We put those two together and identify priority classes.

Once we do that, we will then go to those reservoirs, and that will be field work to determine what we need to do in those reservoirs to preclude abandonment and to enhance recovery.

Mr. SMITH. Okay. The Department of Energy has requested, I think, $17 million for that consortia that you mentioned a while ago, the joint industry-university consortia, which I fully support. Tell us a little bit more about that, why it's important, how you expect it to work.

Mr. GENTILE. Well, let me backtrack just a bit. We have really anticipated some of the work that will be undertaken under the National Energy Strategy. As we're going through this National Energy Strategy process, we've found that, not surprisingly, the decline in domestic production and the threat of abandonment is a serious question, it's a serious problem, and it's come to the forefront.

So the Admiral has acknowledged that, and in the process of developing these plans, we know that this is going to fit when we move forward in the strategy. Given that, this is sort of the first step in that strategy. The $17 million we're talking about right here really comes out of three areas: $10 million comes out of enhanced oil recovery, $4 million, I believe, comes out of unconventional gas, and $3 million comes out of the advanced budget.

Basically, it's based on all three plans. It's going to be competitive, it's going to be 50 percent cost-shared, and we're just starting off a program that's going to be a 10- to 15-year program. This is the beginning stages of it. The first thing we're going to do is look at the reservoirs, identify the common geologic characteristics, identify those reservoirs with the highest potential of bypassed oil——

Mr. SMITH. I thought you had already identified those reservoirs.

Mr. GENTILE. We've done it in some areas. We're doing it in additional areas right now. We're relooking at all the reservoir classes to make sure that our characterization is right. We have not done Appalachia yet, we have not done Alaska or offshore. We've done it primarily in three States. We got the best information—Texas——

Mr. SMITH. Let me ask you a provincial question. Those States have been assigned top priorities. Is that the case?

Mr. GENTILE. Yes, the three States with the best information are New Mexico, Texas and Oklahoma, and they probably have the highest potential. It's one of the most likely areas, yes.

Mr. SMITH. What kind of time table do you have for exploring those particular reservoirs?

Mr. GENTILE. We hope to have all the additional information done, I think, by the end of this year. Let me turn to Marvin here, if I could, please. Marvin may know some more specifics.

Mr. SINGER. We expect the information on the 17 additional States over and above the first three——

Mr. SMITH. Well, I have to confess to you my interest is in one particular State of the first three, not the other 17.

Mr. BRUCE. Go ahead and see if you hit Illinois. [Laughter.]

Mr. SINGER. Well, Illinois is among the 17 additional States that we're collecting data for, and we expect that to be completed sometime later this summer.

Mr. SMITH. Okay, let's go back to those first three, seriously, and the West Texas reservoirs. Tell me the time table on that particular area.

Mr. SINGER. Well, we're folding all of the States together. It's truly a national program, and when we finish the 17 additional States, then all of the reservoirs will be looked at with respect to the potential production and the risk of abandonment in order to rank reservoirs in all of the States.

Mr. SMITH. Once again, when do you expect that process to be completed?

Mr. SINGER. Well, we expect the data collection to be completed later this summer and the ranking to be done after that, sometime this fall, and then the next step will be the identification of the first two classes of reservoirs. And these aren't States, these are classes of reservoirs which are in more than one State.

Mr. SMITH. Do you expect all of that to be finished by the end of this year?

Mr. SINGER. Yes, we expect the identification of the first two reservoir classes by early fall and then public meetings at which we will explore the problems that operators in these classes of reservoirs face in producing in these reservoirs. That's the next step in the program.

Mr. SMITH. I'll be back in touch with you on some of the details. I appreciate your answers.

Thank you, Mr. Chairman. I don't have any other questions.

Mr. BRUCE. I think he'll probably contact you about West Texas, but I don't want to preempt him from asking about Illinois when he asks those other questions.

Mr. Gentile, I was just curious about the preparation of this budget, as I look down the figures with the negative numbers, and I wonder how much does this reflect your thought and DOE's thought, and how much does it reflect the thoughts of OMB?

Mr. GENTILE. Well, Congressman, it doesn't reflect my personal thought. I wasn't around at the time this budget was developed, so it doesn't reflect my thought. The process is that Fossil Energy makes a request through the Secretary and the Secretary through OMB, but I think it's a combination of both.

The Secretary was very much interested in striking a balance and doing some enhanced work in oil and gas and in taking a new initiative in oil and gas, which we've done. It's a new element of the program. There are some ideas, however, that OMB, of course, has to strike a balance between what they've got available and what needs to be done, so it's a combination of competing factors and limited funds.

Mr. Bruce. In your 42 percent reduction in Control Technology and Coal Preparation, do you know what programs are going to be deleted, and, if so, do you know whether the private companies will pick those up? Have you made any attempt to continue that research?

Mr. Gentile. In the coal prep area, we've completed the TRW project, the EPRI project, we're using prior year funds to run the third fine coal cleaning tests in 1991. The major 1991 effort has been——

Mr. Bruce. Is there money in the budget to complete that study in 1991?

Mr. Gentile. We don't need anymore money. We're using leftover 1990 monies.

Mr. Bruce. Okay.

Mr. Gentile. In the flue gas cleanup, we continue work on the tung scrubber, we're supporting the EPRI high sulfur test——

Mr. Bruce. Will that project continue or be stopped with this budget level?

Mr. Gentile. These are reductions, but they're general, across the board reductions, but we're continuing in all these areas. In other words, we're not cutting out any projects. We're slowing some of the projects down, but we're not cutting them out.

Mr. Bruce. How do you continue all your projects—I mean—it appears to me they had a lot of excess funds they didn't need, or they're not doing what——

Mr. Gentile. No, it means that we're drawing them out. It doesn't mean that we're cutting any projects out. In the flue gas cleanup, for example, there are projects that are being stretched out but not eliminated.

Mr. Bruce. So on the flue gas, let's just stay with that, what was your proposed completion date in the original RFP, and what's your proposed completion date now?

Mr. Gentile. It will be about a six- to eight-month stretchout.

Mr. Bruce. Is that standard? That's still within the fiscal year, six or eight months, unless you straddle fiscal years.

Mr. Gentile. Beyond the end of the fiscal year. It will go beyond the end of the fiscal year.

Mr. Bruce. And the other projects? How long are they going to be stretched, on the average? Are they all going to be stretched six to eight months?

Mr. Gentile. They're all multi-year projects, and the staff is telling me they're all looking at about the same time frame. The project dates will be stretched out six to eight months.

Mr. Bruce. Do you have any plans in fiscal year 1991 to request any new proposals for any new research projects?

Mr. Gentile. In 1992, we'll be looking at new projects, but not in 1991.

Mr. Bruce. So the net affect of this is to stop all proposals in 1991 and then pick up the ball again in 1992?

Mr. Gentile. Yes.

Mr. Bruce. Is that a wise policy where we stop all research funding?

Mr. **Gentile**. I'm sure it's not a wise policy in any of these situations, Mr. Chairman. Putting on a technology hat, we wish we had all the money to do everything we'd like to do. But, again, it's a situation where we don't, and we had to select very carefully the priorities and not end funding on any projects we need to continue, so it was a matter of prioritizing given funds.

Mr. **Bruce**. You were starting down a list of other projects. How long is the list?

Mr. **Gentile**. Gas stream clean-up project, the funding is completed. Major efforts in 1991 on pressurized fluidized bed, we're doing some fabric and crossload filter R&D. In the integrated gasification combined cycle, we're doing some particular tests at Wilsonville, ING zinc ferrite tests. In turbines, we're doing bed filters, back-up to the sliding combustors, we're still doing supporting R&D in membranes.

In waste management, we've got a funding increase to support the fourth field test cell to be selected, so we're still doing work in all those areas.

Mr. **Bruce**. I'm curious, on combustion systems, that also has a 41 percent proposed reduction on pressurized fluidized beds, and I'm concerned about your Foster-Wheeler project and how that relates to the American Electric project selected in round one.

Mr. **Gentile**. Well, the Foster-Wheeler project is an advanced pressurized fluidized bed combustor. What we've got going on at the AEP project, we've got a slip stream, and we're testing some gas there that will be built right into the more advanced pressurized fluidized bed at Foster-Wheeler. That is ongoing.

The first generation of fluidized bed is about 40 percent efficiency. The advanced has got the advantage of being about 45 percent efficient with lower electricity costs, so we're very interested in that project. It is continuing on schedule.

Mr. **Bruce**. With a 47 percent reduction in your budget? In combustion research, I see a negative $17 million.

Mr. **Gentile**. The staff is telling me Foster-Wheeler is not the issue. We have the funds in Foster-Wheeler. There were some slippages, but not in Foster-Wheeler.

Mr. **Bruce**. How does that affect American Electric Power's project?

Mr. **Gentile**. It doesn't.

Mr. **Bruce**. Both those projects are going forward, even with a reduction by half?

Mr. **Gentile**. The American Electric Power project in Ohio is ongoing, it's coming on line, I think, in October, it's going to slow down the gas stream clean up, the slip stream, the R&D portion that we have but it's not going to do anything other than to slow that down a little bit.

Mr. **Bruce**. What projects will be slowed down or stretched in combustion research?

Mr. **Gentile**. Let me turn this over to Jack Siegel, please.

Mr. **Siegel**. In the Combustion Systems Program, there are four programs—atmospheric fluidized bed combustion, pressurized fluidized bed combustion, alternative fuels, and advanced combustion technology—and a wide variety of projects within each one.

In some cases, the funding will not affect projects at all. Either they were fully funded previously, or they don't need any funding in 1991, or the project has been completed. In other cases, there might be some slippages, some drawing out of the projects for six to eight months. Six to eight months is a typical period of time for delay of the projects. If you'd like, we can provide for the record the details of that.

Mr. BRUCE. Will you be requesting any additional proposals in fiscal year 1991?

Mr. GENTILE. In 1991, no. In fiscal year 1992, we're evaluating that right now.

Mr. BRUCE. So there's a possibility you wouldn't ask for any additional research dollars in fiscal year 1992?

Mr. GENTILE. There's a possibility that we would not, but that's under review right now.

Mr. BRUCE. So should we perceive from this and my prior questioning on your advanced research and technology and control technology and coal preparation that you're going out of the business of research in these areas?

Mr. GENTILE. No, I don't think so at all. We're still continuing in fiscal year 1991 almost all of the projects we had in fiscal year 1990 but, in some cases, at reduced levels of effort.

Mr. BRUCE. You see, generally, you would complete projects you let in 1991 in 1992. But if you don't ask for any proposals in 1991, you won't have any need for funding in 1992. I agree with the six to eight months and all that, but you've got a whole year there in which you don't plan to ask for any research projects in either one of these two programs.

Mr. GENTILE. That's not the case. We are asking for budgets in fiscal year 1991, not at the same level that Congress appropriated funds in 1990, granted, but we are asking for funds, and, in addition, in a number of these projects, there are carryover funds from fiscal year 1990.

Mr. BRUCE. Can you provide for the record the amount of carryover funds you plan to utilize to continue existing programs, the amount of funds that will be utilized out of your fiscal year 1991 budget to continue existing programs, and the amount of 1991 funding presently proposed that will be used to start new programs funded in 1991 and carried into 1992?

Mr. GENTILE. Certainly.

[The information to be supplied follows:]

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Subcommittee: Energy Research and Development
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The following is a list of FY 1991 activities within Control Technology and Coal Preparation and Combustion Systems which are continuing with carry over funds, continuing with FY 1991 funds, or are new starts.

Activities continuing with carry over funds:

- o Control Technology and Coal Preparation
  - Coal Preparation - (1) testing of the Gravimelt integrated system; (2) DOE/EPRI testing of project initiated in FY 1990; (3) cooperative agreement with State of Illinois for high sulfur coal research.
  - Flue Gas Cleanup - (1) copper oxide process evaluation; (2) two large scale advanced flue gas process contracts awarded in FY 1989.
  - Waste Management - wastewater treatment R&D applicable to western coal processing.
- o Combustion Systems
  - PFB Combustion - advanced PFBC systems component R&D.
  - Advanced Combustion Technology - Phase II development for industrial/utility applications.
  - Alternative Fuels Utilization - (1) DOE/Italy Super Clean Coal Water Slurry project; (2) firetube boiler tests of super clean coal water fuels; (3) natural gas reburn/cofire testing and related natural gas cofiring evaluations.

Activities continuing with FY 1991 funds:

- o Control Technology and Coal Preparation
  - Advanced Research - all research activities ($1,659,000).
  - Coal Preparation - (1) investigations of microbial concepts for pyrite and organic sulfur removal ($936,000); (2) clean coal research initiative ($7,900,000); (3) in-house research and program management support ($2,622,000).
  - Flue Gas Cleanup - (1) acid rain control technologies ($5,029,000); (2) NOx/SOx research, advanced separation research, fine particulate control, enhanced mass transfer, emissions control from small scale boilers ($2,424,000); (3) NOx emissions control ($1,100,000).
  - Gas Stream Cleanup - all research activities ($8,503,000).
  - Waste Management - UNDEERC research, field monitoring of disposed wastes, in-house research, program management support ($2,174,000).
- o Combustion Systems
  - Advanced Research - all research activities ($2,159,000).
  - AFB Combustion - (1) experimental and analytical erosion studies, innovative AFB development efforts and program management support ($382,000); (2) low rank coal studies ($167,000); (3) advanced concepts proof-of-concept testing ($402,000); (4) special applications subsystem development ($286,000).
  - PFB Combustion - (1) in-house research on combustion characterization and system analysis ($892,000); (2) begin construction phase of TIDD test facility project ($1,401,000); (3) Phase III Advanced Concept subsystem tests ($5,100,000); (4) technical and program management support ($75,000).

- Advanced Combustion Technology - (1) Phase III system development for industrial/utility and small scale/commercial applications ($1,596,000); (2) high efficiency/low emission boiler systems development ($1,000,000); (3) in-house research on pollution suppression/removal ($776,000); (4) project and program management support ($337,000).
- Alternative Fuels Utilization - (1) fuel characterization and boiler tests of beneficiated coal-based fuels ($247,000); (2) fuel handling, storage and transport studies ($604,000); (3) in-house research to access deeply beneficiated coal based fuels ($1,869,000); (4) project and program management support ($330,000).

New Starts

o Control Technology and Coal Preparation
  - Coal Preparation - oil and gas displacement initiative ($732,000).
  - Flue Gas Cleanup - CO2 emissions control initiative ($50,000).
  - Waste Management - initiate laboratory characterization of advanced technology wastes ($400,000).

Mr. **Bruce**. Thank you.

Are there further questions of Mr. Gentile?

[No response.]

Mr. **Bruce**. If not, we thank you for your attendance and your testimony here today.

Mr. **Gentile**. Thank you, Mr. Chairman.

Mr. **Bruce**. Our next panel consists of Mr. Hugh McCastlain of the American Gas Association; Mr. David Webb of the Gas Research Institute; and Dr. Paul Tarman of the Institute of Gas Technology.

If you gentlemen will come forward and be seated.

We will begin with Mr. McCastlain and work down the table, and because we're having a little feedback, if you can keep the microphone in the middle and turned off until it's utilized, I think we'll have less rebound in the room here.

Mr. McCastlain, welcome to the Committee, and we look forward to hearing your testimony.

STATEMENT OF HUGH McCASTLAIN, MANAGER, ENERGY TECHNOLOGY DEPARTMENT, AMERICAN GAS ASSOCIATION, ARLINGTON, VA

Mr. **McCastlain**. Mr. Chairman and Members of the Subcommittee, I appreciate being here, and good morning. I am Hugh McCastlain, the Executive Vice President of Arkla Gas, a natural gas distribution company, serving a five-State area of the central and southern United States. I am participating in the Loaned Executive Program at AGA and am appearing on its behalf today.

Congressional funding of DOE research programs should have the objective of ensuring that the energy component of our Nation's economy will deliver low cost and secure energy, while at the same time improving our environment. This will enable U.S. business and industry to remain competitive in the world economy and reduce our dependence upon foreign energy sources.

The natural gas industry can make contributions toward achieving these objectives. First, natural gas, for most uses, is the most economic, efficient, and environmentally safe fuel to choose from. Secondly, efficient gas-powered co-generation and gas cooling will meet growing energy needs while minimizing the need for expensive increments of large capacity generating plants and the resulting impact on customer rates.

Finally, natural gas can be a significant factor in helping to economically improve our environment. One example is to substitute gas for imported oil-based products. These and other fossil fuels emit more pollutants, and in the case of oil products carry the potential for disastrous spills.

The large natural gas resource base provides a logical method of meeting the Nation's energy objectives. However, to ensure that natural gas can contribute over the long term, research and development is needed to increase economically recoverable gas supplies and improve the efficiency of in-use technologies.

DOE R&D funding is essential for these long term, high risk projects that otherwise could not be undertaken by the private sector. DOE has focused greater attention on natural gas. However, it has not followed up by asking for funding levels for natural gas R&D that reflect natural gas potential use.

We are pleased Congress has recognized this need by authorizing R&D funds greater than that requested by DOE last year. My written testimony outlines our funding recommendations, so I will briefly highlight some program recommendations for fiscal year 1991.

For 1991, the gas industry recommends an authorization of $135.7 million for all DOE gas-related R&D. Specifically, AGA recommends $90.7 million for fossil energy, $27.4 million for conservation, and $17.6 million for renewable energy. Included are the critically important Unconventional and Natural Gas Recovery Program, which we recommend being funded at $23.3 million, fuel cells, natural gas vehicle R&D, and geoscience programs.

For natural gas-powered fuel cells, which are extremely efficient and do not harm the environment, we recommend a total of $40.5 million. While we support a strong program for additional development of phosphoric acid fuel cells, the bulk of our recommended funding is directed toward the development of advanced fuel cells.

Second and third generation molten carbonate fuel cells and solid oxide fuel cells are still years away from commercial use and are therefore critically dependent upon continuity of Federal R&D support to supplement industry efforts.

The emission control requirements of the pending clean air legislation are supported by AGA's recommended $9 million for primary research and demonstration projects for combustion systems and emission control research. Of special note is the need for programs on the use of natural gas in combination with coal and boilers to reduce NOX and SO2 emissions.

We also recommend an increase to $7.8 million in R&D on industrial processes. Using R&D dollars to improve industrial gas-fired equipment and processes will provide a variety of benefits which include lowering consumer prices by reducing manufacturing costs, helping business comply with environmental regulations, encouraging industrial use of gas, which improves gas system load factors and levelizes customer bills.

Vehicle emissions are an extremely important part of the Pollution Program. We in the natural gas industry think that vehicles fueled by compressed natural gas are an answer to this problem, since these vehicles produce only a fraction of the harmful emissions of gasoline-fueled vehicles. By using our own resources, we add to our Nation's security and competitiveness by not importing fuels from other nations.

Therefore, we recommend $10.6 million for R&D for natural gas-powered vehicles, which will include full funding to implement NGV development and demonstration programs authorized under the Alternate Motor Fuels Act and funding for fundamental research needed to maximize the use of natural gas as transportation fuel.

In conclusion, although we recognize the continuing budget deficit places severe constraints on Federal energy research dollars, our total recommendation is higher than in previous years, because we are at a critical point in time where we must lay an energy supply foundation that will support our Nation for years to come.

As the Administration, Congress, and the public focuses on secure energy, clean air problems, energy conservation, and efficient end-use technology, there's a general consensus that natural gas has a larger role to play in solving these problems. We have a large domestic natural gas resource. If we use R&D to develop it and use it, we'll reduce the Nation's reliance on foreign oil and refined products and alternative fuels such as methanol.

We should not allow energy-related economic benefits to accrue to foreign nations when we have a large domestic resource such as natural gas that can be better utilized than it now is for the Nation's energy needs. Therefore, increased Federal funding for gas-related research and development is necessary to implement the national goals. Thank you, and I will be happy to answer questions later.

[The prepared statement of Mr. McCastlain follows:]

TESTIMONY OF HUGH McCASTLAIN
EXECUTIVE VICE PRESIDENT
OF ARKLA
SERVING AS MANAGER,
ENERGY TECHNOLOGY DEVELOPMENT
FOR THE
AMERICAN GAS ASSOCIATION
BEFORE THE SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT
HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
ON THE FY 1991 DEPARTMENT OF ENERGY
RESEARCH AND DEVELOPMENT BUDGET

June 20, 1990

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Madame Chair and Members of the Subcommittee:

I am Hugh McCastlain, Executive Vice President of Arkla Gas, a natural gas local distribution company, serving parts of Arkansas, Louisiana, Texas, Oklahoma and Kansas. I am currently serving as a loaned executive to the American Gas Association (A.G.A.) as Manager, Energy Technology Development, on whose behalf I am appearing. A.G.A. is a national trade association comprised of some 250 natural gas distribution and transmission companies serving over 174 million natural gas consumers throughout the United States. We appreciate this opportunity to present our views on natural gas-related research and development (R&D) conducted or sponsored by the Department of Energy (DOE).

The natural gas industry recommends an authorization of $135.7 million for all DOE gas-related R&D in Fiscal Year (FY) 1991. This total is broken down as follows: $90.7 million for fossil energy R&D; and $27.4 million for conservation R&D, which includes $10.6 million for a natural gas vehicle R&D program; and $17.6 million for renewable energy R&D.

While we agree with statements in DOE's recently published Gas Implementation Plan that the issue is not whether gas is present but how to extract it economically and that what is needed is to assure confidence in the reliability of natural gas supply, we are concerned that the plan focuses only on 3 utilization technologies, one of which is questionable -- conversion of natural gas to liquid transportation fuels. The process consumes more natural gas energy and yields more CO_2 than direct utilization of natural gas as a transportation fuel. Our technical staff is presently reviewing these documents and we will be happy to follow up with a written statement on this issue for the record.

The Importance of Gas-Related Research

The United States needs an adequately funded DOE research program, not only to meet future energy needs and reduce national security risks, but also to remain competitive in today's world economy. Because of natural gas's many positive attributes natural gas-related research should be the most important component of DOE's research program.

Natural gas energy has an important role because its attributes favor its use in a myriad of applications. Natural gas is the cleanest of all fossil fuels. Gas can be used for pollution control by itself and to reduce sulfur and nitrogen oxide emissions of other fossil fuels. Gas can also be used as a vehicular fuel. No other single fossil fuel can be used in as many applications, with the inherent environmental benefits as natural gas. Indeed, natural gas is slated to play a role as a compliance measure in the pending Clean Air Act Amendments.

The natural gas industry's million-mile transmission and distribution pipeline network provides an existing infrastructure to deliver energy and environmental improvements to almost every region of the country. Further, natural gas can be converted into usable energy more efficiently and inexpensively than other fossil fuels. The efficiency of current gas utilization technologies ranges from 98 percent for residential heating to 70 percent for industrial cogeneration and 50 percent for combined cycle turbine systems for electric generation.

Research and development programs can continue to improve end-use appliance efficiency, as well as provide energy supply benefits. DOE's role in natural gas research serves two very important purposes in pursuit of these goals. First, DOE's support of gas supply-related research will ensure the recovery of a larger percentage of the total gas resource base, which, when hydrates are included, is much larger than the current estimates of the economically recoverable gas resource base. The amount of gas that can be recovered from the total gas resource base is directly contingent upon our ability to develop new tools and techniques to recover this gas at commercially viable prices.

In May 1988, the Department of Energy released a study entitled, An Assessment of the Natural Gas Resource Base of the United States. This study concluded that, in the lower 48-states, there are 1,059 trillion cubic feet (Tcf) of gas that can be tapped with existing technology. At the 1988 level of nationwide gas consumption, this amount is approximately equivalent to a 58-year supply. While the number is encouraging, low gas prices have forced new drilling ventures to address only the less risky and shallower deposits where payback on investments is more likely. What remain to be developed are concepts for recovering conventional and unconventional gas at competitive prices. Federal sponsored research is necessary to exert downward pressure on gas exploration and production costs, providing increased confidence that gas will continue to be available at competitive prices.

DOE funding is also needed to make significant improvements in the area of energy efficiency through the development of gas technology. Research of this sort will allow for the more efficient use of our domestic resource, and thereby reduce our nation's reliance on foreign oil. It will also facilitate economic growth by enabling U.S. industry to compete in the global marketplace more effectively, using our own resources and reducing pollution.

We are pleased that Congress has recognized the importance of gas-related research. Over the past few years, Congress has consistently authorized and appropriated much more funding for natural gas R&D than the Administration has recommended, especially in the areas of unconventional gas recovery, geopressured resources, gas-related fuel cells and gas-related conservation programs. We hope that in the development of its National Energy Strategy, DOE will focus more attention on natural gas-research and development.

The gas industry has always recommended funding that is consistent with sound fiscal policy. However, our recommendation for FY 1991 will show increases in fuel cells, natural gas vehicles, heat combustion systems and other industrial technology commercialization funding. Such an increase is cogent public policy and in keeping with the need for least-cost clean air compliance measures.

Specific Funding Recommendations

Fossil Energy R&D: $90.7 Million

(1) Unconventional Natural Gas ($23.3 million)

Large amounts of natural gas have been identified in tight geological formations such as Devonian shales and tight sands. These two sources are estimated to contain more than 1,800 Tcf and 900 Tcf of natural gas, respectively. Tight formation gas is produced using advanced recovery techniques such as hydraulic fracturing. A.G.A. estimates that favorable economic conditions and substantial investment in advanced recovery techniques could increase the accessible gas resources and improve the economics of gas production.

In order to maximize the amount of natural gas recovered from our abundant resource base, basic geoscience research must be expanded. This research should be aimed at increasing our knowledge of the geological/geochemical/geophysical characteristics and parameters of both conventional and unconventional formations. This cross-cutting, reservoir characterization-type research is essential to both exploration and production in new formations, which are characterized by subtle traps, and to the application of secondary recovery techniques in existing fields.

Moreover, because of the potentially enormous size of what we call advanced unconventional natural gas resources, (i.e., gas hydrates and deep source gas) extensive research is necessary to verify how much may be technologically and economically recoverable.

To enhance the development of technology necessary to recover the gas from unconventional gas formations, more research must also be conducted to develop and refine advanced stimulation and drilling techniques. Current fracturing techniques induce only shallow fractures of a few hundred feet. Field testing and a technological database for stimulation modeling, economic modeling and other analytical purposes must also be established. We are recommending funding of $23.3 million in the unconventional gas recovery program to continue DOE's secondary gas recovery program and ongoing research activities in western tight sands, Devonian shales, and other complex formations and to support expanded geoscience-type research.

(2) Surface Coal Gasification ($8.5 million)

Contemporary technologies allow significant production of gas from coal; however, substantial research into the gasification process is necessary for synthesized gas from coal to play a role in meeting this nation's future energy needs. For surface coal gasification to make a significant contribution to gas supplies, gasification techniques must be developed to accommodate high-sulfur Eastern coals and combustion-inhibiting coal "fines". Research must be conducted to develop techniques for gasifying these "fines," for disposition of liquid byproducts, and for consolidated "fines" and tars for utilization. Scientific and engineering feasibility studies of advanced generation gasification processes must also be conducted to develop a technological database for such processes.

(3) Fuel Cells ($40.5 million)

Natural gas-powered fuel cells, in a highly efficient electrochemical process, convert the energy content of gas directly into electricity and byproduct heat. The electrical conversion efficiency of natural gas-powered fuel cells is approximately 15-20 percent greater than the conversion efficiency of traditional electrical generation. Using fuel cells in certain cogeneration applications can achieve combined electrical and thermal conversion efficiencies of 80 percent, compared to conversion efficiencies of 33 percent by conventional coal-burning central station electric powerplants. Fuel cells are also environmentally safe, emitting virtually no pollutants.

The gas industry's focus is directed toward the development of advanced fuel cells, which will operate at higher temperatures making them conducive to industrial applications and achieve even higher efficiencies. Research must be conducted to develop second generation molten carbonate fuel cells capable of processing gases containing various impurities, as well as to develop other advanced, direct conversion concepts, such as solid oxide fuel cells. The second and third generation fuel cell concepts are still years away from commercial use and, therefore, are critically dependent upon continuity of federal R&D support to supplement industry efforts.

Because of the importance of this technology, we recommend a total of $40.0 million for fuel cells. While we support a strong program for additional technology development for phosphoric acid fuel cell powerplants, in view of DOE's budget constraints, we are asking for only $1.5 million in FY 1991. We also recommend that $33.0 million be used to support development of molten carbonate fuel cells, and $6.0

million should be used for continued development of advanced concepts such as solid oxide fuel cell technologies.

(4) Combustion Systems/Emission Control ($9.0 million)

Because of the impact of combustion systems on emission control a combustion research program is needed to support pending clean air act legislation with a $9.0 million recommendation for programs on utility cofiring and reburn technologies, industrial cofiring and combustion research.

Basic cofiring of coal with natural gas involves the injection of gas into the boiler to provide a fraction of its total heat input, resulting in SO_2 and NO_x reductions. Reburn technology is aimed primarily at reducing powerplant NO_x emissions. As in cofiring, reburn involves using gas as a small portion of the boiler fuel. Unlike basic cofiring, however, reburn technology involves injecting that fuel into a zone beyond the primary combustion zone to create a natural gas rich "reburn" zone. Combining reburn with sorbent injection results in both NO_x and SO_2 reductions.

To date, basic cofiring has been tested at one commercially operational plant. Tests of all three cofiring technologies are scheduled to begin at six other power plants within the next year. Two of these projects are in Illinois and the others are located in Indiana, Oklahoma, Ohio and Colorado. These projects are being funded from a variety of sources, including the natural gas industry and, in some cases, the Department of Energy. In all, a total of almost $52 million will be invested in cofiring demonstration projects. While some projects are at the demonstration phase, primary R&D is still needed for testing on different boiler types using different proportions of coal and natural gas and general development of novel efficient and economical emission control approaches.

(5) Heat Engines ($2.9 million)

Heat engines will contribute positively to the environment and energy conservation. Therefore, A.G.A. recommends a research and development program in DOE's Heat Engine Program for the development of high efficiency natural gas-powered turbines for electric generation. Such a program should include advanced combined cycle gas turbines, steam-injected gas turbines (STIG) and intercooled steam-injected gas turbines (ISTIG). The ISTIGs, in particular, are approximately fifty percent more efficient than conventional powerplants, cost half as much as new coal or nuclear plants and can make great contributions to the nation's air pollution problems.

(6) Underground Coal Gasification ($0.5 million)

Underground coal gasification is the process whereby coal is burned underground, in formation generating a low-Btu gas. The coal is gasified by drilling boreholes into the coal seam and igniting it. Underground coal gasification could increase the nation's coal resource base substantially. This resource base may comprise as much as 1.8 trillion tons of coal. Moreover, underground coal gasification offers potential environmental, economic and safety advantages over conventional mining. Extensive field testing, data analysis and environmental monitoring is necessary to develop an adequate understanding of the technical basis for linking vertical wells through the coal seam and controlling the movement of the reaction zone.

(7) Advanced Research & Technology Development ($6.0 million)

The Advanced Research and Technology Development Program generally supports basic research in combustion chemistry, engineering concepts and materials and components that provide a technology base for ongoing fossil energy projects and for advanced process development, such as coal gasification and fuel cell systems. We recommend continued support for these activities.

Conservation: $27.4 Million

(1) Natural Gas-Powered Heat Pumps and Desiccant Cooling ($8.0 million)

The gas heat pump provides heating and cooling in a single unit, using less energy than a conventional or high efficiency furnace uses for heating alone. Current performance estimates suggest that in heating, the gas heat pump could save one-half of the gas used in a conventional furnace and one-quarter of the gas used in a high efficiency furnace.

More research is necessary to develop highly-efficient, reliable and cost-effective gas heat pumps for residential and commercial applications. To improve durability, maintenance and endurance, such research must include the evaluation of promising technical approaches, fundamental research in basic heat pump concepts, processes, phenomena and materials, and research on generic component development. These activities must be integrated into overall gas heat pump system development and analysis.

Likewise, in cooling applications, a variety of technical challenges must be overcome. Needed desiccant improvements include higher performance, reduced equipment size, and improved understanding of the capability of desiccants to remove airborne pollutants, as well as moisture.

(2) Natural Gas Vehicles (NGVs) ($10.6 million)

First and foremost, we recommend full funding for the alternative fueled vehicle demonstrations authorized in P.L. 100-494, the Alternative Motor Fuels Act of 1988. In addition, certain research is needed to improve the use of natural gas as a vehicular fuel. Indeed, in pending clean air legislation Congress has recognized the role of NGVs in cleaning up our nation's air. Research is therefore needed to optimize the use of NGVs.

For example, fundamental research is necessary to acquire a thorough understanding of the intricacies of gaseous fuel injection, carburetor, manifolding, combustion, power optimization and emissions control so that natural gas can become broadly accepted as a transportation fuel. Further research into novel gas compression concepts is necessary to advance the development of gas compressor technology. Research must also be conducted on advanced storage systems (e.g., sorbent materials) to increase the understanding of gas storage technology, particularly the fundamental principles of natural gas adsorption, absorption, clathration and catalysis.

(3) Industrial Processes ($7.8 million)

We recommend an increase to $7.8 million in R&D on industrial processes. Using R&D dollar to improve gas-fired equipment and processes will provide a variety of benefits, including: (1) offsetting consumer price increases by reducing manufacturing costs through increased productivity and process efficiencies and reduced storage, handling, and a preparation cost; (2) enhance a business's ability to expand operations and still comply with environmental regulations on combustion and process emissions; (3) encourage industrial use of natural gas and thus levelize gas flow rates and seasonal load balancing, which in turn assists gas utilities to level gas purchasing costs and customer bills; (4) reduce dependence on imported petroleum and petroleum products; and, (5) contribute to U.S. manufacturing competitiveness in the international marketplace.

(4) Energy Conversion and Utilization Technology (ECUT) ($1.0 million)

Research needs for energy conversion and utilization technology centers on ceramics and other advanced materials. Specifically, research is needed to develop more systematic fabrication techniques for the forming and centering of more reliable ceramic parts. Moreover, reproducible and cost-effective manufacturing and quality control techniques are needed for the large-scale production of reliable ceramic materials and components. ECUT also includes important crosscutting research in the areas of combustion, biocatalyst, and tribology information and technological advancement for the gas industry.

Renewable Energy: $17.6 Million

(1) Geopressured Methane ($9.6 million)

Geopressured methane is found in either a free state or dissolved in water and trapped in sedimentary rock at higher-than-normal pressures. One of the largest geopressured areas underlies a portion of the Texas and Louisiana Gulf Coast. Estimates of the total resource in-place range up to 6,000 Tcf; however, estimates of the amounts of gas that might ultimately be recovered, given current recovery techniques, range between 10 and 150 Tcf. If technological breakthroughs can be achieved, geopressured methane could become another major source of domestic energy.

Research conducted by DOE in geopressured/geothermal zones is focused on producing both gas and electricity from low-grade heat in the reservoir brine. DOE should redirect its research efforts and concentrate on recovering the vast amount of dissolved methane found in geopressured zones. In addition to DOE's current geopressured program, DOE should develop new approaches that utilize traditional engineering principles to maximize gas production and minimize brine production.

(2) Biofuels ($8.0 million)

Since the supply of organic and waste materials is virtually unlimited, supplemental methane supplies from biomass and waste conversion can add significantly to the total future gas supply picture. In addition, controlled production and use of methane from these sources can reduce the natural release of methane from the decay of these waste materials. This decay is a substantial contributor to the overall rate of methane emissions to the atmosphere that contribute to the greenhouse effect. Finding sites for disposal of municipal solid waste is an increasing problem in communities across the nation. Therefore, developing energy from municipal solid waste and other biomass would promote the environmental benefit of productive use of currently "useless" materials. However, the quality of the gas produced and a suitable processing technique are important concerns that inhibit the widespread use of these potential gas resources.

The gas industry fully supports the gas-related biofuels R&D being carried out at the Solar Energy Research Institute (SERI) and recommends strong federal support for continuation of these important activities. Advances have been made in both the thermochemical and biochemical conversion processes, but more extensive studies and technology advancements are necessary to fulfill biomass' contribution as a usable source of energy.

Of particular interest to the gas industry is SERI's work in the biotechnology process of anaerobic digestion of municipal solid waste that includes genetic and other improvement of biological organisms and development of innovative reactor design concepts.

Another significant area of research at SERI includes methods to remove carbon dioxide from the air or from combustion plant stacks. Four million dollars is needed to perform these two gas-related initiatives in FY 1991. We also urge the Congress to provide a strong, stable funding level for all biofuels research work at SERI. This research program has experienced drastic funding cuts in recent years.

Conclusion

The natural gas industry recognizes that the continuing budget deficit places severe constraints on federal energy research dollars. Our total recommendation this year of $135.7 million is higher than previous years because of the increasing urgency to promote energy conservation through more efficient end use technologies. As the Administration, Congress and the public focus on clean air issues, there is a growing consensus that natural gas has a major role to play in solving clean air problems. To achieve this objective there must be increased federal funding for research and development to increase natural gas supplies and utilize gas more efficiently. Our recommendation is still conservative though, since it requests funding for only those technologies that are essential and prudent for the orderly development of new, domestic gas supply and utilization technologies. If Congress adopts our research recommendations, the nation will, over the long term, improve its energy supply security, energy efficiency, and environment.

DOE FY 1991 Gas-Related Budget
Major Gas-Related Research Programs
($ Millions)
(As of 3/07/90)

	FY 1990 DOE Request	FY 1990 Gas Industry Recomm	FY 1990 Congress Approp.	FY 1991 DOE Request	FY 1991 Gas Industry Recomm
ARTD (Gas Related)	3.0	6.0	4.7	3.9	6.0
Fuel Cells (Gas Related)	6.5	36.5	30.1	7.1	40.5
Surface Coal Gasif.	8.7	3.4	23.7	8.5	8.5
Underground Coal Gasif.	0.4	2.5	0.8	0.5	0.5
Heat Engines	0.0	8.0	0.0	0.0	2.9
Combus.--Cofiring/Reburn	N/A	N/A	2.5	0.0	8.5
Combus. Sys/Emiss. Cont.	0.0	2.0	0.0	0.0	0.5
Geosciences	3.0	*	4.0	4.5	*
Unconventional Nat'l Gas	4.1	15.0	14.6	13.7	23.3
Conservation	10.2	29.5	25.4	17.8	16.8
NGV/Diesel Vehicles	0.7	9.5	2.5	4.0	10.6
Biofuels	4.5	5.0	8.6	2.5	8.0
Geopressured Resources	2.9	8.4	6.0	2.9	9.6
TOTAL	$44.0	$125.8	$122.9	$65.4	$135.7

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*While the gas industry is supporting geosciences as a concept, it is not supporting a specific line-item funding level. The industry is, however, supporting a funding level of $10 million for gas-related geoscience work that is included in other line items, _e.g._, Advanced Extraction and Process Technology and Unconventional Natural Gas.

Mr. **Bruce.** Thank you, Mr. McCastlain, for your testimony. I appreciate your comments about the need for domestic supply of fuel.

Mr. Webb, from the Gas Research Institute, we look forward to hearing your testimony.

STATEMENT OF DAVID O. WEBB, SENIOR VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE, WASHINGTON, DC

Mr. **Webb.** Thank you, Mr. Chairman. I'd like to ask that my entire statement be included for the record, and I'd like to summarize here this morning to keep the time short.

Mr. **Bruce.** Without objection, your statement will appear in its entirety in the record.

Mr. **Webb.** Thank you, sir. I appreciate the opportunity to appear before you today to present GRI's recommendations on gas-related research in the Department of Energy's fiscal year 1991 Fossil Energy Program.

Within the GRI recommendation of $135.7 million for all gas-related research in the DOE program, $90.7 million is recommended for fossil energy R&D. In developing these funding recommendations, GRI gave top priority to significant actions required to support a national policy of using domestic natural gas to solve our environmental problems while reducing our dependence on imported oil.

Central to the funding recommendations is the fact that GRI's planned 1991 budget of approximately $62 million for near term research in these same fossil energy programs. GRI is an independent, not-for-profit research organization that plans, manages and finances a cooperative R&D program for its 314 members and their customers.

National energy R&D policy is a major factor influencing the R&D program, since GRI co-funds and coordinates approximately $30 million a year annually with DOE. Even though GRI is not a Government contractor, Congressional action on the proposed fiscal year 1991 budget has a direct impact on the gas industry's R&D program.

Natural gas can play a significant role in meeting the United States' future energy demand and has the potential to make a meaningful contribution in cleaning up the environment. Natural gas is in abundant supply in the United States and is our Nation's cleanest burning fossil fuel. Thus, increasing the use of gas is one cost effective approach to helping solve the Nation's environmental problems.

In determining whether it's feasible to increase gas use as a key element of national energy policy, we need to first examine the gas resource base. The critical question is whether the capability exists for additional cost competitive domestic gas production.

DOE had a recent study, an assessment of the natural gas resource base in the United States, that showed there was a technically recoverable resource base of 1,059 trillion cubic feet of natural gas in the lower 48 States. The recovery of much of this gas requires discovery and development of new technology. Furthermore, more than half of the total resource evaluated by DOE, 583 trillion cubic feet of gas, was just to be economically recoverable at prices of less than $3 per MCF at the wellhead with the development of advanced technology.

Therefore, it is clear there is no gas resource limitation that would preclude the expanded role for gas in the U.S. energy economy. The uncertainties of gas supply are not resource limitations. Rather they are the pace of technology innovation and the pace of new investment that will be necessary to sustain increased levels of gas production.

The next question, then, is, can technology make a difference in developing this identified gas resource base? GRI's projections of U.S. energy supply and demand indicate that the incremental lower 48 gas production resulting from advanced technology will provide 14 percent of U.S. gas supply by the year 2000 and 23 percent by 2010. We project this advanced technology will come from Devonian shale, tight formations, coal seams and coal production of gas and water from existing fields.

This contribution can only be achieved with advanced technology development. GRI expects that these advanced technologies will begin to become available in the early 1990s; however, this will be achieved only through an expanded and directed joint DOE-gas industry near term gas supply R&D program.

This program becomes even more critical when you evaluate the decline that's projected in production from conventional reservoirs; specifically, high permeability gas, primarily current production practices, which accounted for almost three-fourths of the lower 48 gas production in 1988. By 2010, GRI projects it will account for less than 50 percent of lower 48 production, thus clear that advanced technology be a major factor if the United States is to solve some of its near term environmental problems through a policy expanding domestic gas use.

The reality of the DOE fiscal year 1991 budget request is, however, that DOE is clearly proposing to fund an inadequate level of gas-related R&D. The total DOE request for gas-related research for fiscal year 1991's Fossil Energy Program is only $33.6 million, less than one-half of last year's appropriation of $76.4 million.

Furthermore, the funding request for unconventional gas R&D, which I was just talking about is a valuable resource, is $13.7 million, less than 2 percent of the proposed fossil budget, including clean coal. The budget request is inadequate and does not support a policy of increasing gas use to solve environmental problems.

An expanded joint R&D effort between the gas industry and DOE is required. To fund this joint effort, GRI recommends $90.7 million. Of this amount, $23.3 million should be R&D for unconventional natural gas. Also, DOE should continue its ongoing, long term R&D in fuel cells, coal gasification and unconventional gas. The near term research we would recommend would be funded primarily through cooperative R&D ventures.

The Department of Energy stated in its fiscal year 1991 Congressional budget request that one of the primary goals of all the applied research in fossil energy is to effectively transfer technology from Federal and university laboratories to the U.S. private sector. "The earlier the U.S. industry or their trading consortium representatives are involved," DOE went on to state, "the more directly that the research agenda is guided for the company's own economic self-interest, therefore the more effective the transfer of technology is likely to be."

GRI hardily agrees with this approach and encourages DOE and Congress to expand the concept of cooperative R&D ventures. With the industry's willingness to assume day-to-day management control and to invest more than 50 percent of the project funding, the Government can achieve its policy objectives. As an example of cooperative ventures, GRI is currently providing the dominant share of private sector funding to one of the first Federal-private sector cooperative R&D ventures under a pilot program in secondary gas recovery established by DOE's Fossil Energy Program in September 1988.

Specific examples of other gas supply cooperative R&D ventures GRI proposes for DOE participation in funding are in western tight sands. A cooperative venture focusing on the development of the stimulation production technologies for the tight sands formation is urgently needed. Funding of $3 million in fiscal year 1991 is the DOE's share of that cooperative venture.

Another one being water drive reservoirs. We'd recommend $2 million of DOE funding to initiate a joint venture in that with industry. And in eastern Devonian shales. A cooperative R&D venture similar to the one in secondary gas recovery is recommended. The DOE funding of $3 million is needed in fiscal year 1991.

Also, I'd like to briefly comment on DOE's Natural Gas R&D Program plan. In the fiscal year 1991 budget request, DOE requested $13.6 million for gas supply R&D, and while this request is slightly less than the $14.6 million appropriated by Congress last year, it is encouraging compared to previous budget requests.

In the four years prior to fiscal year 1991, DOE's average budget request for gas supply R&D was $3.2 million. Even though Congress appropriated approximately $10 million per year for these four years, long term planning for a cooperative, comprehensive R&D program could not take place, because DOE's planning was not based on a multi-year program consistent with the appropriated levels but with their requested levels. Therefore, funding for any project that extended beyond one year was not assured, and you just could not plan a cooperative program.

DOE has now developed a Natural Gas R&D Program implementation plan with a base case five-year funding level of approximately $22 million per year. We would urge this Committee and Congress to provide funding to implement that plan. The gas industry, through GRI, would be pledging approximately $35 million for cooperative ventures and other R&D in this area. We think that can make significant progress, and we think it's urgent and important.

Also, we would say that the DOE program with their Geosciences Research Program, which has $4 million of the $17 million directed to gas supply, should be considered part of that. So for unconventional natural gas in DOE, we'd be talking about $20 million a year to implement their plan, plus the $3 million or $4 million a year in their geosciences.

In summary, Mr. Chairman, an expanded gas R&D effort in DOE's Fossil Energy Program is needed to ensure a stable, reliable energy mix for this Nation's security. Furthermore, as public and

Federal attention focuses on environmental issues such as acid rain and global warming, it is time to increase R&D in those gas-related areas such as fuel cells, natural gas vehicles, unconventional natural gas, and gas co-firing and reburn that address environmental needs.

GRI recommends funding of $90.7 million in the DOE Fossil Energy Program for gas-related research in fiscal year 1991. We believe this budget recommendation is consistent with the past policy of Congress and recognizes the need for a balanced energy policy and the need for additional research to help solve our environmental problems.

Thank you, Mr. Chairman. I'd be pleased to try to answer any questions.

[The prepared statement of Mr. Webb follows:]

STATEMENT OF

DAVID O. WEBB
SENIOR VICE PRESIDENT
POLICY AND REGULATORY AFFAIRS
GAS RESEARCH INSTITUTE

BEFORE THE

SCIENCE, SPACE AND TECHNOLOGY COMMITTEE
U.S. HOUSE OF REPRESENTATIVES

JUNE 20, 1990

STATEMENT OF
DAVID O. WEBB
SENIOR VICE PRESIDENT, POLICY AND REGULATORY AFFAIRS
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SCIENCE, SPACE AND TECHNOLOGY COMMITTEE
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JUNE 20, 1990

I appreciate the opportunity to appear before you today to present Gas Research Institute's (GRI) recommendations for gas-related research in the Department of Energy's (DOE) FY 1991 Fossil Energy Program. (See Exhibit I.) Within the GRI and the gas industry's recommendation of $135.7 million for all gas-related research in DOE's FY 1991 budget, $90.7 million is for fossil energy R&D. In developing these funding recommendations, GRI gave top priority to the need to develop the United States' extensive domestic gas resources in order to make a significant contribution to solving our environmental problems and to reducing our dependence on imported oil. Central to the funding recommendations is the fact that GRI's planned 1991 budget includes $61.66 million for research in the same fossil energy program areas in 1991.

GRI is an independent, not-for-profit scientific research organization that plans, manages, and finances a cooperative R&D program for the benefit of its 314 members and their customers. The R&D program is implemented through contracts with research organizations, engineering firms, universities, energy companies, and manufacturers. National energy R&D policy is a major factor influencing the R&D program since GRI cofunds and coordinates approximately $30 million annually of its research projects with DOE. Therefore, even though GRI is not a government contractor, Congressional action on the proposed FY 1991 budget has a direct impact on the gas industry's R&D program.

NATURAL GAS--THE FUEL FOR THE 90s

Natural gas can play a significant role in the United States' energy balance and has the potential to make a meaningful contribution in cleaning up the environment. Natural gas is in abundant supply in the United States and is our nation's cleanest burning fossil fuel--its combustion emits virtually no particulates, sulfur oxides, or reactive hydrocarbons, and it produces far lower emissions of nitrogen oxides and carbon monoxide per unit of energy than coal or oil. Thus, increasing the use of gas is one cost-effective approach to solving the nation's environmental problems.

To assess whether it is feasible to increase gas use as one key element of national energy policy, we need to consider current natural gas demand and to examine the gas resource base. Estimated consumption of natural gas in 1988 was 18.1 quads (see Table I). Current domestic production is running slightly below that at 17 quads annually with the balance of demand met by other sources, i.e., storage, supplemental gaseous fuels and natural gas imports. The critical question is whether the capability exists for additional domestic production.

Table I
1989 GRI Baseline Projection
of Gas Supply Trends
(Quads)

	Actual 1988	1995	2000	2010
Lower-48 Production	15.6	15.0	16.1	15.6
Alaskan Production	0.2	0.2	0.2	1.5
Pipeline Imports	1.3	1.9	1.9	1.8
LNG Imports		0.5	0.8	1.0
Coal Gas	0.1	0.1	0.1	0.1
Other Gas	0.1	0.2	0.2	0.2
Total	17.3	17.9	19.3	20.2
Lease & Plant Fuel	1.2	1.1	1.2	1.2
Total Supply	18.5	19.0	20.5	21.4
Losses & Exports	0.4	0.4	0.4	0.4
Total	18.1	18.7	20.2	20.9

Numbers may not add due to rounding.

A recent Department of Energy study, An Assessment of the Natural Gas Resource Base of the United States (May 1988), shows that a technically recoverable resource base of 1,059 trillion cubic feet (Tcf) of natural gas exists in the lower-48 states (See Table II). This resource base is made up of proved reserves, inferred reserves, and resources. The recovery of gas in the resources category requires discovery and development of new technology, some using improved understanding of reservoir geometry. More than half of the total resource evaluated in the lower-48 states (583 Tcf of gas) is judged economically recoverable at less than $3/Mcf (wellhead prices, 1987$). An additional 174 Tcf of gas is judged economically recoverable in a price range of $3 to $5/Mcf.

Table II
Comparison of Recent Estimates of
U.S. Natural Gas Resources
(Tcf)

	DOE	PGC	GRI
Lower-48 Proven Reserves	159	154	159
Undiscovered Resources	900	678	978
Total Lower-48	1059	832	1127
Alaska	129	152	N/A
Total U.S.	1182	984	N/A

It is clear there is no gas resource limitation that would preclude an expanded role for gas in the U.S. energy economy. The uncertainties of gas deliverability are not resource limitations. Rather, they are the pace of technological innovation and of new investment that will be necessary to sustain the levels of gas production needed in the future.

Role of New Initiatives in Gas Supply Outlook

The next question, then, is, "Can technology make a difference in the gas resource base?" The gas resource base accessible to U.S gas users under current industry practices generally reflects the 1970s perceptions of that resource base. Under current practice (base technology), U.S. gas production was sustained primarily by the discovery of new fields and reserve appreciation in known fields using traditional development practices. Less conventional sources (e.g., Devonian shale, tight sands, coalbed methane) played a very minor role in industry activity. These sources were generally considered to require very high prices and/or new technology.

In the 1980s, new initiatives began to expand the perception of the gas resource base available to the U.S. gas user. New technologies and practices (advanced technology) developed in the 1980s or expected in the future indicate that less conventional gas sources can play a substantial role in future gas supply, even without high prices.

Table III categorizes the supply sources in the 1989 GRI Baseline Projection by current practice or new initiatives. Current practice supply declines through the projection period. The increased gas supply in the 1989 projection arises from the growing role of new initiatives in the U.S. gas supply picture.

Table III
U.S. Gas Supplies--1989 Baseline Projection
(Quads)

	1988	1995	2000	2010
Current Practice				
U.S. Production, Base Technology	17.0	15.2	14.7	12.0
Canada	1.3	1.9	1.9	1.3
LNG	a	0.5	0.8	0.8
Supplemental Sources	0.1[b]	0.3	0.3	0.3
	18.5	17.8	17.6	14.4
New Initiatives				
U.S. Production	0.0	1.2	2.9	6.3
Lower-48 Advanced Technology	--	(1.2)	(2.9)	(5.0)
Alaska	--	--	--	(1.3)
Imports	0.0	0.0	0.0	0.7
Canada Frontier	--	--	--	(0.3)
Mexico	--	--	--	(0.2)
LNG	--	--	--	(0.2)
	0.0	1.2	2.9	7.0
Total Supply	18.5	19.0	20.5	21.4

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[a] Less than 0.05 quad
[b] Includes net supply from storage

The lower part of Table III presents the portfolio of new initiatives sources. The incremental lower-48 gas production resulting from advanced technology provides 14 percent of U.S. gas supply by 2000 and 23 percent by 2010. The advanced technology production is from Devonian shale, tight sands, coal seams, and watered-out reservoirs.

The advanced technology production does not include any contribution from improved gas recovery from high-permeability gas reservoirs using more intensive drilling. The recent DOE gas resource study indicated that with advanced technology the resource exceeds 120 Tcf at $3/Mcf. GRI has begun its own analysis of this resource potential, and the first basin analysis has been completed. GRI's study concludes that with improved technology almost 7 Tcf of gas can be recovered from the producing sections in the San Juan Basin at an average levelized cost of less than $2.50/MMBtu (1988$).

The contribution of advanced technology production will depend on the pace at which the predictability and reliability of new production techniques can be demonstrated and brought into widespread (i.e., "conventional") use. GRI expects that these advanced technologies will begin to become available in the early-1990s. This will be achieved only through an expanded and directed near-term supply R&D program to make advanced technology available and widely applied on a timely basis.

Table IV distributes the lower-48 gas production in the 1989 GRI projection among gas resource categories. The role of high-permeability gas, which reflects the role of new field discoveries, declines substantially over the projection period. High-permeability gas is estimated to account for almost three-fourths of lower-48 gas production in 1988. By 2010, high-permeability gas accounts for less than 50 percent of lower-48 production.

Table IV
Lower-48 Gas Production Gas Resource Categories
1989 GRI Baseline Projection
(Quads)

Category	1988	1995	2000	2005	2010
High Permeability	12.5	11.1	10.7	9.5	7.7
Low Permeability	1.3	2.4	3.0	3.6	3.8
Devonian Shale	0.1	0.2	0.4	0.8	1.2
Coalbed Methane	a	0.3	1.0	1.3	1.3
Coproduction	--	0.1	0.2	0.3	0.5
Associated Gas	3.0	2.1	2.0	2.0	2.1
Total	16.8	16.0	17.2	17.4	16.6

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[a] Less than 0.05 quad

However, Table IV shows that coalbed methane and low-permeability production grow substantially over the projection period with more of the growth occurring by the year 2000. Devonian shale gas production also grows substantially, but most of this growth does not occur until after the year

2000. Coproduction gas grows relatively steadily through the projection. The growth in these resource categories is driven by the availability of advanced technology.

It is clear that advanced technology will be a major factor if the United States is to solve some of its near-term environmental problems through an expanded role for natural gas. What is needed is an aggressive federal/gas industry joint R&D effort during the next five years.

PROPOSED JOINT DOE/GAS INDUSTRY R&D PROGRAM

The reality of the DOE FY 1991 budget request is, however, that DOE clearly is proposing to fund an inadequate level of gas-related R&D. The total DOE request for gas-related research funding for the FY 1991 Fossil Energy Program is only $33.6 million, less than one-half of last year's appropriation of $76.4 million (see Table V). Furthermore, the funding request for unconventional natural gas R&D is $13.7 million, less than 2 percent of the proposed Fossil budget including the Clean Coal Program. The budget request is inadequate and does not support a policy of increasing gas use to solve environmental problems.

Table V
Gas-Related Research Recommendations
for DOE FY 1991 Fossil Energy Program
($ Millions)

($ Millions)

	FY 1989 Approp.	FY 1990 Approp.	DOE FY 1991 Request	FY 1991 Gas Industry Recommend.	GRI Planned Budget 1991*
ARTD (Gas-Related)	$ 6.00	$ 4.70	$ 3.90	$ 6.00	$ 4.22
Fuel Cells (Gas-Related)	17.03	30.10	7.08	40.50	3.75
Coal Gasification	23.82	24.50	8.95	9.00	1.55
Gas Cofiring/Reburn	0.00	2.50	0	9.00	10.70
Heat Engines (Gas-Fueled)	3.00	0.00	0	2.90	5.50
Unconventional Natural Gas	12.38	14.60	13.67	23.30	35.94
Fossil Energy Total	$62.23	$76.40	$33.60	$90.70	$61.66

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*Preliminary estimate--not yet FERC-approved.

An expanded joint R&D effort between the gas industry and DOE is required. To fund this joint effort, GRI recommends $90.7 million for DOE's Fossil Energy gas-related research budget. DOE should continue important ongoing long-term R&D in fuel cells, unconventional natural gas, and coal gasification. Cooperative R&D ventures should be funded to conduct near-term research, especially in tight gas formations, Devonian shale, secondary recovery of natural gas, and gas cofiring/reburn.

GAS POLICY INITIATIVE: EXPAND COOPERATIVE R&D VENTURE CONCEPT

The Department of Energy stated in its FY 1991 Congressional Budget Request that "one of the primary goals of all the applied research in Fossil Energy is to effectively transfer technology from Federal and university laboratories to the U.S. private industry. The earlier the U.S. industry and/or their trade and consortia representatives are involved, and the more directly that the research agenda is guided by the companies' own economic self-interest, the more effective the transfer is likely to be."

GRI heartily agrees with this approach and encourages DOE and Congress to continue and to expand the concept of cooperative R&D ventures. Under the cooperative R&D venture concept, once the government and the venture sponsors contractually agree to the program scope, schedule, and funding, the government relinquishes day-to-day management control in exchange for a majority share of funding from the private partners. DOE would monitor and advise rather than manage the project and would reenter the decisionmaking process in the event of changes to the program scope, schedule, or funding. This approach to government/private sector collaborative research provides the private partner with the flexibility to assess the market, as well as the capabilities and needs of the various players, to form a project structure and management plan specifically designed to develop the technology and move it along the path towards successful entry into the marketplace. Through industry's willingness to invest its own resources (at least 50 percent of the project funding), the government is paying less than half of the cost of a project that it judges to be in the public interest.

As an example, GRI is currently providing the dominant share of private sector funding to one of the first federal/private cooperative R&D ventures under a pilot program established by DOE's Fossil Energy Program. In September 1988, GRI, DOE, and the Bureau of Economic Geology (BEG) at the University of Texas at Austin agreed to cofund a cooperative R&D venture on extended reserve growth in gas reservoirs, called secondary gas recovery. The purpose of the three-year, $22.25 million project is to develop and test technologies and methodologies with near-term potential to identify and recover bypassed gas, trapped gas, and gas from deeper horizons thus maximizing additional gas recovery from known fields.

Initial emphasis will be placed on formations near the Texas Gulf Coast which contains some of the most productive gas fields in the nation. DOE has estimated that about 120 Tcf of natural gas is recoverable by extended reserve growth in nonassociated gas reservoirs in the lower-48 states. About 45 Tcf of this resource is estimated to exist in Texas. Economic recovery of these additional reserves will have a major impact on our energy future.

Under the terms of the agreement, GRI will provide the dominant share of research funds and will be responsible for managing the project. The BEG will serve as principal contractor and will coordinate the activities of the subcontractors. The Morgantown Energy Technology Center (METC) will monitor and provide advice on the project for DOE, as well as provide input from complementary programs under way at METC.

Independent gas producers, oil field service companies, and major gas producers will be integrally involved throughout the project. After laboratory work has progressed, studies will be conducted cooperatively with producer/operators, who are drilling commercial wells in the selected regions. This strategy provides a cost-effective means of collecting data and performing interim tests of research progress. Data from the cooperative wells will be used in selecting sites for research wells (termed Staged Field Experiment, or SFE, wells). These SFE wells will be drilled specifically for R&D purposes--for example, to confirm or challenge interim R&D results and to test state-of-the-art technologies. The results of the secondary gas recovery cooperative R&D venture will be made available to natural gas producers nationwide.

Future Cooperative Ventures

GRI is proposing to fund with DOE cooperative R&D ventures that are beneficial to society at large. Specific examples of cooperative R&D ventures that would be appropriate for DOE participation and funding are listed below.

1. Western Tight Sands. Significant amounts of potentially recoverable natural gas exist in low-permeability sandstone formations located in sedimentary basins throughout the United States. Current information indicates that the total amount of economically recoverable gas from tight sands could exceed 500 Tcf. However, a combination of technical limitations and economic constraints prevent the widespread commercial exploitation of these resources. It is estimated that the development of advanced technologies and practices applicable to tight gas sands could provide an additional 200 Tcf of cost-competitive gas over what is recoverable with present state-of-the-art technology. A cooperative DOE/industry R&D venture focusing on the longer-term development of stimulation production technologies for the tight sands formations is urgently needed. Funding of $3 million in FY 1991 is required from DOE.

2. Water-Drive Reservoirs. An estimated 500 Tcf of technically recoverable natural gas (50 Tcf of which is estimated to be economically recoverable) exists in water-drive reservoirs in the form of trapped gas. The gas becomes trapped as a result of the encroachment of water into production wells. Once high levels of water production are reached, the traditional production practice is to plug and abandon the affected gas wells and ultimately the gas field. Recent data have indicated that the recovery efficiencies for the prolific water-drive gas reservoirs along the Texas-Louisiana Gulf Coast are 50 percent or less. A cooperative R&D venture requiring DOE funding of $2 million in FY 1991 could assist technical efforts which are needed for additional gas recovery from watered-out reservoirs.

3. Eastern Devonian Shales. The large eastern Devonian gas shales resource base underlies approximately 175,000 square miles of the eastern United States. Current information indicates that the gas-in-place is approximately 2000 Tcf; however, large uncertainty exists regarding how much of that resource may be recoverable. There is an opportunity for a cooperative DOE/GRI effort to enhance gas recovery from shales in a program quite similar to the previously mentioned cooperative R&D venture in secondary gas recovery. DOE funding of $3 million is needed to initiate this effort in FY 1991.

4. Gas Cofiring/Reburn. Current concern about acid rain will result in legislative requirements to substantially reduce SO_2 and NO_x emissions from both industrial and electric utility boilers fired with fossil fuels. Approaches such as gas cofiring/reburn, which use natural gas to augment coal or oil firing, have the potential to provide a cost-effective, near-term retrofit option for emissions control. While DOE and GRI already have joint projects in gas reburn and gas cofiring in coal-fired utility boilers, a project is needed to address the issue of emissions in nonutility boilers. A basic cofiring field test in an industrial boiler is required. DOE funding of $4 million in FY 1991 is proposed to initiate a cooperative R&D venture.

DOE'S NATURAL GAS R&D PROGRAM PLAN

In the FY 1991 budget request, DOE requested $13.6 million for gas supply R&D. While this request is slightly less than the $14.6 million appropriated by Congress last year, it is encouraging compared to previous budget requests. Despite the obvious need for a significant DOE R&D effort in natural gas supply, in recent years, the DOE budget requests have been very small and inadequate. In the four years prior to FY 1991, DOE's average budget request for gas supply R&D was $3.2 million. (See Table VI.) Even though Congress has appropriated approximately $10 million per year for these four years, long-range planning for a cooperative R&D program could not take place because DOE did not plan a program consistent with the appropriated budget level. Therefore, funding for any project that extended beyond one year was not assured.

Table VI
DOE Natural Gas Supply R&D Budget Request
($ Millions)

FY 1987	FY 1988	FY 1989	FY 1990	FY 1991
$5.3	$1.6	$1.7	$4.1	$13.7

Now DOE has developed a Natural Gas R&D Program Implementation Plan with a base case five-year funding level of approximately $22 million per year. This plan is encouraging and can form the basis for developing a joint DOE/gas industry natural gas supply R&D program. Furthermore, the Plan has increased emphasis on near-term R&D and technology transfer through joint efforts with industry. GRI believes that the large potential for gas to help solve U.S. environmental problems and the very large gas resource base in the lower-48 states fully justify an annual DOE program of approximately $25 million. This level of funding over the next five years coordinated with the gas industry's program that is funded and managed by GRI will allow significant progress. GRI's planned budget for natural gas supply R&D in 1991 is $36 million.

The natural gas R&D programs at DOE and GRI must be coordinated to ensure that R&D is targeted to meet near-term deliverability needs and to ensure long-term basic research on speculative gas resources is continued. This coordination should be based on the following basic principles:

- Avoid duplication
- Emphasize cooperative R&D ventures for near-term applied R&D and field tests
- GRI continues its lead role in technology transfer
- DOE continues its lead role in environmental R&D and speculative resources

To ensure these principles are incorporated in both GRI and DOE program planning, GRI is planning to meet with DOE Fossil Energy policy officials to further define the role of each organization.

RELATIONSHIP OF DOE'S GEOSCIENCE INITIATIVE TO NATURAL GAS R&D

In the FY 1991 budget, DOE proposed a $17 million geoscience initiative. When evaluating the relationship between the geoscience initiative and DOE's Natural Gas R&D Plan, it is important to realize only $4 million of the $17 million initiative is directed toward natural gas R&D. The remainder of the geoscience funding is $10 million for enhanced oil recovery and $3 million for advanced extraction and process technology.

Obviously, the $4 million requested for natural gas geoscience research should be coordinated with and should supplement the Natural Gas R&D Plan. Primarily, the $4 million should be used for expansion of reservoir characterization efforts in natural gas conventional reservoirs and for resource assessment in deep sediments.

The $4 million for natural gas geoscience research should be considered part of the total funding for the DOE natural gas supply R&D program. Therefore, to implement the base case natural gas supply budget in the DOE Natural Gas R&D Program Implementation Plan, $20 million is required in the unconventional gas line item in addition to the $4 million in geosciences. GRI urges Congress to fund the geoscience initiative and the $20 million for unconventional natural gas R&D.

PROPOSED DOE FY 1991 GAS-RELATED RESEARCH PROGRAM

An expanded effort in DOE's Fossil Energy Program is needed to ensure a stable, reliable energy mix for this nation's security. To fund this joint federal/industry R&D effort, GRI and the gas industry recommend $90.7 million research budget in fossil energy. In many cases, projects are being coordinated or cofunded with the gas industry. Congress has recognized the need for a viable DOE gas-related program and appropriated approximately $76.4 million last year for these DOE programs (See Table VII).

Table VII
Gas-Related Research Recommendations for DOE FY 1991 Fossil Energy Program
($ Millions)

	FY 1989 Approp.	FY 1990 Approp.	DOE FY 1991 Request	FY 1991 Gas Industry Recommend.	GRI Planned Budget 1991*
ARTD (Gas-Related)	$ 6.00	$ 4.70	$ 3.90	$ 6.00	$ 4.22
Fuel Cells (Gas-Related)	17.03	30.10	7.08	40.50	3.75
Coal Gasification	23.82	24.50	8.95	9.00	1.55
Gas Cofiring/Reburn	0.00	2.50	0	9.00	10.70
Heat Engines (Gas-Fueled)	3.00	0.00	0	2.90	5.50
Unconventional Natural Gas	12.38	14.60	13.67	23.30	35.94
Fossil Energy Total	$62.23	$76.40	$33.60	$90.70	$61.66

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*Preliminary estimate--not yet FERC-approved.

Recommended DOE FY 1991 Gas-Related Program Budgets/Fossil Energy

Budget request levels continue to be far below what is necessary to conduct critical gas-related R&D in DOE, and Congress has consistently increased these budgets to provide an uninterrupted funding level for ongoing research. In order to attract industrial funding partners in this research effort, it is necessary to maintain a continuity in funding and support for these ongoing programs.

The gas industry, through GRI, is investigating technologies to use gas to address environmental issues. To continue these initiatives, the gas industry recommends some increases over past years' recommendations for DOE's FY 1991 budget for fuel cells, gas/coal combustion activities, and unconventional natural gas. This increase is tied to technologies which would allow DOE to use natural gas to address environmental concerns.

Following is a recommendation for specific programs of particular interest to GRI and the gas industry.

Fossil Energy

Western Tight Sands	FY 1989 Appropriation	FY 1990 Appropriation	DOE FY 1991 Request	FY 1991 Recommendation
	$3.325 Million	$3.519 Million	$2.98 Million	$5.0 Million

Gas-bearing tight sands occur in the form of blanket-type and lenticular formations. In both types, the effects of a variety of interdependent parameters are still unknown, and consequently, the gas recovery rate and active reservoir life for a given field remain uncertain. To permit low-cost exploitation of the full potential of the tight sands resource base, the following specific technological issues need to be addressed:

1. Determine the relationship between geologic and engineering parameters;

2. Further characterize tight sands gas reservoirs and improve resource estimates;

3. Identify the parameters critical to formation evaluation and gas production;

4. Understand more clearly the mechanisms of hydraulic fracture propagation and control;

5. Diagnose fracture shape and downhole conditions using surface parameters;

6. Provide real-time fracture treatment design changes; and

7. Apply advanced technologies to presently noncommercial areas.

GRI has concentrated its efforts in the near-term aspects of blanket-type formations such as resource characterization, formation evaluation, fracture diagnostics, and real-time analysis development. GRI's planned 1991 budget for tight gas sands is $11.3 million. In addition, it is expected that industrial partners will contribute another $3.75 million. GRI recommends that DOE commit $5 million for research in the tight sands formations.

	FY 1989 Appropriation	FY 1990 Appropriation	DOE FY 1991 Request	FY 1991 Recommendation
Eastern Devonian Shales	$3.075 Million	$3.319 Million	$2.69 Million	$3.0 Million

In general, two major factors constrain present-day exploitation of this resource: (1) the inability to predict with confidence the gas production rates that will be obtained in wells drilled outside of historical production areas, and (2) the inconsistent response of formations to currently employed stimulation practices. Because most of the producers in the Appalachian Basin are small independents, they cannot afford to conduct the comprehensive R&D required to understand and solve these problems.

Barriers to economic production of natural gas from Devonian shales include:

1. Inadequate understanding of factors that control the flow of gas from Devonian shale formations to the wellbore;

2. Lack of effective exploration rationales to identify geographic areas and stratigraphic zones with highest production potential;

3. The need for improved diagnostic methods to assess the potential of productive zones;

4. Inadequate understanding of shale gas reservoir dynamics; and

5. Lack of generally effective stimulation techniques.

Economic exploitation of the full resources hinges on development of improved techniques and technologies for overcoming these limiting factors.

GRI's program in eastern Devonian shales includes reservoir evaluation, recovery enhancement methods, geologic production controls, and development of a resource well information data base. GRI's planned 1991 budget for eastern Devonian shales is $5.5 million with an additional $3 million in industrial funding expected. The gas industry recommends a total of $3 million for DOE research of eastern Devonian shales.

	FY 1989 Appropriation	FY 1990 Appropriation	DOE FY 1991 Request	FY 1991 Recommendation
Secondary Gas Recovery	$2.5 Million	$3.01 Million	$.65 Million	$3.0 Million

A significant quantity of natural gas requiring minimal exploration and in close proximity to gathering systems and pipelines is known to exist in currently producing and abandoned wells and fields. These potential reserve additions consist of (1) bypassed gas in currently producing or temporarily abandoned wells, (2) untapped reservoir compartments in existing fields, and (3) gas trapped by the encroachment of water in water-drive reservoirs.

To ensure the timely development of technologies for near-term production of bypassed gas and gas from undiscovered reservoir compartments in developed fields, the following specific technological issues need to be addressed:

1. Improved understanding of geologic environments and characteristics of gas fields to allow for more accurate resource identification and estimates,

2. Provision of an accurate methodology for cased-hole formation evaluation, and

3. Development of in-field reexploration rationales based on a better understanding of reservoir heterogeneities.

By addressing these issues, gas producers can exploit appropriate elements of the conventional resource base in the near term at market-clearing prices. Over the longer term, application of these technologies can increase gas reserves and deliverability of low-cost gas through more effective and efficient development of fields yet to be discovered.

In addition to bypassed gas and gas from undiscovered reservoir compartments in developed fields, an estimated 100 Tcf of technically recoverable natural gas (50 Tcf of which is estimated to be economically recoverable) exists in water-drive reservoirs in the form of trapped gas. Recent data have indicated that the recovery efficiencies for the prolific water-drive gas reservoirs along the Texas-Louisiana Gulf Coast are 50 percent or less, leaving large quantities of gas trapped in reservoirs.

Currently, GRI's program addresses resource characterization, coproduction of trapped gas and water, and brine treatment and control. An initiative undertaken in 1988 was research into the undiscovered reservoirs in known fields. This Secondary Gas Recovery program is cofunded with the Department of Energy, GRI, the State of Texas Bureau of Economic Geology, and producers under a cooperative R&D venture.

GRI's planned 1991 budget for secondary gas recovery is $7.9 million with an additional $4.27 million expected from industry. The recommendation to DOE is $0.65 million to complete the Secondary Gas Recovery Program and the remaining $2.35 million to initiate a joint program in coproduction of gas and water.

Gas Cofiring/ Reburn	FY 1989 Appropriation	FY 1990 Appropriation	DOE FY 1991 Request	FY 1991 Recommendation
	$ 0	$2.5 Million	$ 0	$9.0 Million

Current concern over acid rain will result in legislative requirements to substantially reduce SO_2 and NO_x emissions from both industrial and electric utility boilers fired with fossil fuels. Present technologies for reducing these emissions from boilers fired with coal and oil are capital-intensive and have high operation and maintenance costs (scrubbers). Approaches using natural gas to augment coal or oil firing may provide a cost-effective retrofit emission-control solution.

A reburn project currently in progress, located at the Ohio Edison's 108 MW cyclone boiler at the Niles Powerplant will demonstrate a technology using natural gas combusted with coal to reduce emissions. The cost is estimated to be $10.7 million. GRI, the Electric Power Research Institute, Consolidated Natural Gas, Ohio Edison, the Environmental Protection Agency (EPA), the Ohio Coal Development Office, and DOE are all cosponsors.

Reburning is uniquely well suited as an in-furnace NO_x reduction technique for cyclone-fired boilers, which produce significantly more NO_x than wall-fired or tangentially-fired boilers. Cyclone-fired boilers contribute about 21 percent of the NO_x emitted by pre-New Source Performance Standards (NSPS) coal-fired units even though cyclone-fired boilers represent about 14 percent of the pre-NSPS coal-fired capacity. Since the cyclone combustor cannot tolerate significant changes in its operation without creating other operational problems, the cyclone combustor is limited to an in-furnace NO_x reduction technology. The only operation change required with reburn is that the primary fuel-feed rate be reduced in the primary combustor with an equivalent amount (on Btu basis) of fuel injected in the reburn zone, usually not more than 20 percent of the total fuel input. The excess air, and therefore the air/fuel stoichiometry within the cyclone, can be held constant, thereby lessening the potential for cyclone operational problems. Based on past research, the conservative expectation is that NO_x will be reduced in a cyclone-fired boiler using gas reburn by at least 50 to 60 percent.

The system design and fabrication phases of the Niles plant project have been completed. Plans are to install the reburn system during the regular boiler maintenance outage scheduled for May, 1990. Baseline tests and parametric tests of the reburn system will follow the installation of the system for approximately six to nine months. The six-month performance test is scheduled to start in the spring of 1991. The project will be completed in April 1992. DOE's share to complete this project is $500,000.

Other R&D would be valuable in assessing the potential of gas used in conjunction with more polluting fuels to reduce emissions. Additional projects should include a reburn field evaluation on an oil-fired utility boiler at a cost of $4.5 million. In addition to work on utility boilers, it would be useful to address the issue of emissions in non-utility boilers by testing basic cofiring in an industrial boiler at a cost of $4 million.

A total of $9 million is recommended in FY 1991 for DOE to cost share in cofiring combustion activities. Of this amount, $500,000 is required to complete DOE's contribution to the Niles project. GRI's proposed FY 1991 budget for emission control technologies in combustion totals $6.25 million. Industry participation is expected to total $10 million

Fuel Cells	FY 1989 Appropriation	FY 1990 Appropriation	DOE FY 1991 Request	FY 1991 Recommendation
(Gas-Related)	$17.034 Million	$30.1 Million	$7.08 Million	$40.5 Million

A fuel cell uses natural gas in an electrochemical process to produce electricity and heat. This is accomplished with very high overall energy efficiency, good reliability, low noise, and virtually no pollutants.

Advanced fuel cell technology offers three important operating benefits : (1) electrical efficiencies of 45 to 63 percent, (2) high temperature operation (1300°-2000°F) offering high-quality thermal energy, and (3) ability to use natural gas directly without extensive reformer equipment. Two types of advanced fuel cells appear promising: the solid oxide (ceramic) fuel cell (SOFC) and the carbonate fuel cell (CFC). SOFC technology is promising because of its potential for high-power-density cell stacks, its solid state construction which eliminates the liquid electrolyte, and its potential as a simpler and less expensive system than the carbonate type. Major R&D efforts are needed, however, on cell fabrication technology and durability before detailed SOFC system development can be undertaken.

Research on CFC technology is being conducted for use primarily on central-station electric generation. Although the development of CFCs has proceeded further than solid oxide systems, major development efforts are still needed in the cell stack area (power section) before the CFC can be commercialized. These efforts include activities that have long development times and represent major technological hurdles: electrode performance and durability, electrolyte management, corrosion, thermal cycling, integration of stack components, and improved fabrication technologies.

GRI's planned 1991 budget for fuel cell activity is $2.6 million with an additional $4 million from industrial partners. The gas industry recommends a total DOE budget of $40.5 million for molten carbonate and solid oxide fuel cells and for a generic program in phosphoric acid fuel cells. Of this total funding, $9 million should be allocated to SOFC and $5 million should be allocated to phosphoric acid fuel cells.

SUMMARY

GRI recommends funding of $90.7 million in the Department of Energy's Fossil Energy FY 1991 budget to continue a viable, consistent gas-related research program that adequately addresses the needs of this nation's gas supply and environmental concerns. This funding will continue the programs Congress has already approved in past years and would increase emphasis on gas uses to address environmental concerns. We believe this budget recommendation is consistent with the past policies of Congress and recognizes the need for a balanced energy policy and the need for additional research to solve environmental problems. It should be noted that the gas industry is funding research in these program areas with a GRI R&D budget of approximately $62 million.

Exhibit I
Gas-Related Research Recommendations for DOE FY 1991 Fossil Energy, Conservation, and Solar and Renewables Programs
($ Millions)

	FY 1989 Approp.	FY 1990 Approp.	DOE FY 1991 Request	FY 1991 Gas Industry Recommend.	GRI Planned Budget 1991*
Fossil Energy R&D					
ARTD (Gas-Related)	$ 6.00	$ 4.70	$ 3.90	$ 6.00	$ 4.22
Fuel Cells (Gas-Related)	17.03	30.10	7.08	40.50	3.75
Coal Gasification	23.82	24.50	8.95	9.00	1.55
Gas Cofiring/Reburn	0.00	2.50	0	9.00	10.70
Heat Engines (Gas-Fueled)	3.00	0.00	0	2.90	5.50
Unconventional Natural Gas	12.38	14.60	13.67	23.30	35.94
Fossil Energy Subtotal	$62.23	$76.40	$33.60	$90.70	$61.66
Conservation R&D					
Heat Pumps & Desiccant Cooling	$ 7.87	$ 6.62	$ 5.70	$ 8.00	$22.18
Industrial	4.60	9.13	6.30	7.80	15.60
ECUT (Gas-Related)	13.42	10.67	4.30	1.00	12.88
Indoor Air Quality/Bldg Sys Res	1.39	1.40	1.50	N/A	4.08
Natural Gas Vehicles	0.00	4.50	4.00	10.60	5.10
Conservation Subtotal	$27.28	$31.90	$21.80	$27.40	$59.84
Solar & Renewables R&D					
Biofuels (Gas-Related)	$ 6.50	$ 8.60	$ 2.50	$ 8.00	$ 2.05
Geopressured Resources	6.00	6.00	2.90	9.60	**
Solar & Renewables Subtotal	$12.50	$14.60	$ 5.40	$17.60	$ 2.05
Total Fossil Energy, Conservation, & Renewables	$102.01	$115.60	$ 60.80	$135.70	$123.55

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*Preliminary estimate--not yet FERC-approved.

**GRI's geopressured funding is included in unconventional natural gas line item.

Mr. **Bruce**. Thank you, Mr. Webb. We appreciate your testimony. We will hear from Dr. Tarman, and then we'll ask questions of the entire panel.

Dr. Paul Tarman, from the Institute of Gas Technology, we welcome you to our hearing this morning and look forward to your testimony.

STATEMENT OF DR. PAUL TARMAN, VICE PRESIDENT, RESEARCH AND DEVELOPMENT, INSTITUTE OF GAS TECHNOLOGY, CHICAGO, IL

Dr. **Tarman**. Thank you. Good morning, Mr. Chairman. My name is Paul Tarman, I'm Vice President of Research and Development at the Institute of Gas Technology.

Mr. Chairman, January 1990 was an historic month. For the first time in history, we imported over half our oil product demand, and our dependency on foreign oil continues to grow. This trend cannot be reversed unless we develop new environmentally acceptable technologies that compete economically with imported oil.

The natural gas industry has addressed these issues by recommending a wide range of gas-related research programs. IGT strongly supports this position. Today, I would like to discuss a few of those programs.

Coal is this country's largest energy resource. We have almost one-third of the world's total recoverable reserves. We must find new environmentally acceptable ways to use this vast resource. One of these is mild gasification. Mild gasification produces a broad slate of valuable byproducts. IGT is one of four research teams working on mild gasification. Our technology can process all ranks of coal, including highly caking eastern bituminous coals.

To date, we've conducted over 40 tests with Illinois and West Virginia coals and established the operating conditions to achieve liquid yields of up to 30 percent. We have used these data for the preliminary design of a 24-ton-per-day process development unit and are ready for scale-up. IGT recommends that $8.5 million be authorized to support DOE's Mild Gasification Program, including $4 million for construction of a 24-ton-per-day PDU applicable to all ranks of coal, including eastern caking coals.

Eastern oil shale is another vast yet untapped energy resource, located in States where energy markets, mining, transportation and refining infrastructures already exist. Two new technologies—pressurized fluidized bed hydroretorting, or PFH, now under development at IGT, and the KENTORT II process being developed by the University of Kentucky—could, once fully developed, yield up to 600 billion barrels of oil from eastern shales.

The PFH process is now ready for scale-up. We've conducted almost 100 laboratory tests in which we have optimized oil production and minimized hydrogen consumption for six different types of eastern oil shale. The results show oil yields of up to 270 percent of Fischer Assay using 45 percent less hydrogen than a moving bed hydroretorter. Although the KENTORT process yields less oil, a wider range of marketable byproducts is produced.

In order to move these two technologies closer to maturity, IGT recommends that $8.5 million be authorized for the eastern oil shale initiative also. This includes $5.5 million to continue the PFH development and construct a one-ton-per-hour process development unit and $755,000 for continued support of the KENTORT II technology and related environmental studies.

Natural gas is our cleanest burning fuel. Demand is sure to rise, especially in view of our current clean air initiative. IGT is working on the production of our huge geopressured geothermal methane resource in the Gulf Coast area. This resource contains over 5,700 quads of geopressured natural gas. If only 10 percent were produced, it would add more than 30 years to our domestic supply of natural gas. A like amount of energy is contained in the geothermal heat of the hot brine.

However, a better understanding of this resource is needed to predict the long term capacities of both the reservoirs and the brine disposal aquifers so that viable economics can be established for recovering this energy.

Three wells are being investigated for DOE: the Gladys McCall and Hulin Wells in Louisiana, and the Pleasant Bayou Well in Texas. So far the program has had significant accomplishments. We've proved that this resource exists in reservoirs large enough for commercial production, we've demonstrated long term production and disposal of brine at commercially acceptable flow rates—up to 30,000 barrels per day—and we've produced electricity using both the combustion heat of the natural gas and the thermal energy in the hot brine. All of this has been accomplished in an environmentally benign manner.

After producing nearly 30 million barrels of hot brine and 700 million cubic feet of natural gas, the Gladys McCall Well is now ready for final testing. A short term test program is now required to determine whether prolonged production has changed the permeability of the rock in the reservoir. This information is needed to determine the long term potential of geopressured geothermal reservoirs.

Testing of a one megawatt power plant at the Pleasant Bayou Well has just been completed. This was the first demonstration of producing electricity from both the geopressured gas and the geothermal brine. This well should now be operated at high flow rates for a prolonged period to determine the size and quality of this reservoir.

The Hulin Well, which is the deepest and hottest of the three wells, may contain free gas over and above that dissolved in the brine. Surface facilities are needed at Hulin so that scientific experimental data can be obtained, especially at high flow rates. These same facilities could then be used at Gladys McCall and Pleasant Bayou. IGT recommends that $9.6 million be authorized to continue acquisition of scientific data at these three wells.

Gasification of our municipal waste is another means of preserving our domestic gas supply while simultaneously solving our critical shortage of environmentally acceptable landfill sites. Because of this shortage, many municipal waste incinerators are being installed to produce electricity from our MSW. However, incineration produces emissions, including dioxins in some cases, and incineration is not the most efficient means to produce electricity from this resource.

IGT has developed a fluidized bed gasification process, which we call Renugas, that is non-polluting and more efficient than incineration. It's a flexible process that can produce methanol, fuel gas or electricity. Incineration produces only electricity. Furthermore, Renugas is more efficient than incineration, producing about 40 percent more electricity and releasing 25 percent less in carbon dioxide per unit of electricity produced.

To advance this technology, IGT recommends that $1 million be authorized to begin a two-year program to apply Renugas to the production of clean fuels by gasifying MSW in existing process research unit at IGT.

Finally, Mr. Chairman, IGT strongly supports the testimony that you will hear from M-C Power later regarding the need to increase molten carbonate fuel cell funding to the $30 million level so that all three development teams can continue stack research and commercial scale-up.

That concludes my verbal testimony, but I would like to point out that I have included a few other recommendations for your consideration in my written testimony.

[The prepared statement of Dr. Tarman follows:]

STATEMENT BY PAUL TARMAN
VICE PRESIDENT, RESEARCH AND DEVELOPMENT
INSTITUTE OF GAS TECHNOLOGY
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
June 20, 1990

Madam Chairman, January 1990 was an historic month. For the first time in our history, we imported over 50% of our oil and oil product needs. Such reliance on imported energy was not attained even during the worst periods of the 1970's energy crises. In 1989, oil imports increased more than 8% above 1988, accounting for 45% of our 1989 trade deficit.

These increases are not due to increasing demand; worse yet, they are at the expense of our domestic production. Domestic oil output decreased by more than a half-million barrels per day in 1989, and is expected to fall an additional 350,000 barrels per day this year. This trend will continue unless we develop new technologies that compete economically with imported oil. We need short-term solutions to meet current demand, but we also need long-term solutions to reverse this trend. The lead times for bringing our most promising technologies to market are long, requiring careful and adequately funded research and development. Furthermore, these technologies must be energy efficient while simultaneously maintaining a sound commitment to environmental protection and stewardship.

Attention to energy and environmental policies is a growing public concern. The President has joined the Congress in pushing clean air legislation, while the Secretary of Energy has taken on the enormous task of formulating a comprehensive National Energy Strategy for the future. Today's voters look more closely at the environmental records of candidates. Utility users are more willing to pay increased rates as long as those increases produce more environmentally responsible technologies. This trend will surely accelerate.

With the tremendous global political changes that have occurred in recent months, perhaps the most positive "peace dividend" is the opportunity to focus both our dollars and our technical skills on these energy and environmental challenges. With the world looking to us as a model of democracy, we must also be prepared to offer clean, safe, efficient technologies that solve the world's energy needs as well as protect its air and water.

The natural gas industry has offered the Congress a set of recommendations that address both the energy and environmental issues. These gas-related Department of Energy research programs total $135.7 million for FY91. IGT strongly supports this position, which promises more efficient use of our natural gas resources. All our energy resources must be developed. No one resource alone, even our coal, which has an energy value more than one and a half times all the known oil and gas resources in the world, can solve these problems. What happens if the clean air debate this year negates the use of much of our coal resource?

The Congress and the scientific community must work together in selecting the proper technical menu so that scarce federal funds can be wisely spent on energy and environmental solutions that are both politically desirable and technologically achievable. As our reliance on imported energy continues to worsen, federal programs must increase the pace of our search for new sources of domestic energy at a delivery cost that caps world energy prices.

The most difficult task in establishing priorities falls to the Congress. The technologies we recommend today are for advanced development, and by definition bear significant levels of risk and uncertainty of success. The whole role of federal funding is not in avoiding risks, but in assuming risks worth taking on behalf of our national interest.

It is in that spirit, Madam Chairman, that IGT emphasizes the following specific recommendations for FY91 funding:

EASTERN OIL SHALE:

Eastern oil shale is a vast, yet untapped, energy resource located in states bounded by Alabama, Michigan, Pennsylvania and Illinois--states where energy markets, mining, transportation and refining infrastructures already exist. Technologies designed specifically for producing oil from Eastern oil shale have advanced significantly under DOE contracts. IGT has developed a pressurized fluidized bed hydroretorting (PFH) process that has increased the oil yields from Eastern shale and significantly lowered the per barrel cost. The KENTORT II process has made similar gains. Both programs include comprehensive environmental impact and potential market analyses. This vast domestic energy resource could deliver over 600 billion barrels of oil for our future energy supply. To move these Eastern oil shale technologies closer to maturity,

> **IGT recommends $8.5 million, including $4.35 million to initiate the scale-up of the PFH process to a one-ton/hour process development unit, $1.15 million for further cost-effective improvements in the PFH process and an evaluation of the market qualities of its oils and byproducts, $375,000 for continued support of the KENTORT II technology and $380,000 for continuation of environmental studies on Eastern shale.**

MILD GASIFICATION OF COAL:

Our country has 29% of the world's total recoverable coal reserves, and our coal resource has an energy value one and a half times larger than all the known oil and gas in the world. Finding new, environmentally sound ways to use our coal resources, particularly through the production of value-added byproducts, will allow us to continue to benefit from this vast energy supply. IGT is one of four research teams developing mild gasification technologies. To support this program,

> **IGT recommends $8.5 million for mild gasification of coal, including $1.5 million for continued co-product research using IGT's current facilities, $4.0 million to continue the construction of the first PDU, and $3.0 million to initiate a second PDU if necessary to demonstrate mild gasification of all ranks of domestic coal.**

NATURAL GAS SUPPLY:

Natural gas is a clean burning, efficient fuel, and we can significantly increase our domestic supply by recovering as much of the gas present in known reservoirs as possible and by identifying new sources of natural gas.

IGT's experience in investigating the use of inert gas to sweep natural gas out of underground storage facilities should now be applied to recover the gas left in natural gas reservoirs by current production technologies.

To find new domestic sources of natural gas, the experience gained through DOE-funded research in deep gas wells should be applied to investigating deep sedimentary basins where large quantities of gas may exist. Research needs to be done both in determining the presence of gas at the lower layers of these basins and in investigating the porosity and permeability of the rock at these depths.

To advance these areas,

IGT recommends $1.75 million for a program to increase the natural gas supply in the U.S. by using inert gas injection to increase recovery of natural gas and for a program to investigate the feasibility of natural gas production from deep sedimentary basins in the U.S.

SUBQUALITY GAS UPGRADING:

The usable natural gas resource in the U.S. can be substantially increased if the subquality gas already discovered could be economically upgraded. The Gas Research Institute has estimated that up to 137 TCF of known domestic gas reserves are currently unusable because of the levels of carbon dioxide, nitrogen or hydrogen sulfide contamination.

Under DOE contract, IGT has developed expertise in designing and manufacturing thermal energy storage materials. By tailoring a thermal storage material specifically to the temperature and heat release characteristics of a pressure swing absorption (PSA) system, making it both isothermal and adiabatic, current PSA technologies could be adapted to efficiently and economically upgrade subquality natural gas in fields where that is not now feasible.

IGT has also discovered a microorganism that rapidly removes essentially all hydrogen sulfide from subquality gas, using carbon dioxide also found in subquality gases to convert hydrogen sulfide to easily removable elemental sulfur. Biological and engineering studies are necessary to determine the optimum approach for using a process based on this microorganism to bring currently unusable subquality gas to market.

To advance these technologies,

IGT recommends $0.75 million for the development of IGT's Isothermal Adiabatic Pressure Swing Adsorption (IAPSA) and microbial gas upgrading processes to upgrade subquality natural gas.

METHANE ENHANCED CHEMICAL SYNTHESIS:

IGT has been developing novel approaches for using methane. One such technology utilizes an IGT microorganism which metabolizes methane to form a catalyst which converts certain classes of chemicals into oxygenated single stereo isomers, high-value chemicals which can now only be produced through expensive chemical or biological processes. Single stereo isomers have unique characteristics in such things as biodegradability, strength, elasticity, biocompatability, optical clarity or electrical conductivity, properties which may have significant new industrial value.

A second technology applies an IGT proprietary catalyst and process to use methane to convert saturated hydrocarbons into unsaturated hydrocarbons, thus converting a chemical feedstock that is currently in abundant supply into one which has significantly higher value and for which there is high demand.

Because further research is needed to advance both these technologies,

IGT recommends $0.8 million to develop a biological process, using IGT's technique, to convert certain classes of chemicals into oxygenated single stereo isomers and to develop, in a project currently coordinated with GRI and IGT, technology to convert saturated hydrocarbons into more valuable unsaturated hydrocarbons, thus expanding our feedstock supplies.

MOLTEN CARBONATE FUEL CELLS:

Molten carbonate fuel cells are highly efficient, virtually pollution-free devices for producing electricity. Under the current DOE program, they are being designed to be fueled by gasified coal but, as this subcommittee knows from hearings earlier this year, they can be fueled by any source of hydrogen such as natural gas. Their design flexibility will allow utilities to add incremental capacity at dispersed sites which makes them ideal for cogeneration applications. The United States is currently the world leader in developing molten carbonate fuel cells, and IGT's IMHEX^R internal-manifolding approach, currently being commercialized by M-C Power, offers a unique solution for fuel cell construction.

To continue to advance this technology,

IGT recommends $30.0 million for the molten carbonate fuel cell program, divided among the three current development teams, to continue the full system development and scale-up of two of the current design approaches representing the broadest possible technical diversity, and continue stack research on the remaining design.

GEOPRESSURED/GEOTHERMAL METHANE:

The current DOE Geopressured/Geothermal program is directed toward solving the technical issues inhibiting the economic development of the huge U.S. geopressured/geothermal resource in the Gulf Coast area. These reservoirs consist of thousands of trillion cubic feet (TCF) of natural gas and a like amount of energy in hot brine.

Private industry has recently formed a coalition to coordinate potential uses of this resource. This group includes both major and independent oil companies, utilities and companies involved in food growing and processing, horticulture and aquaculture.

The Hulin, the deepest and hottest of the three wells currently being tested under the DOE program, is also the only test well that has the potential for free gas in addition to the gas dissolved in the brine. In FY91, more comprehensive testing is required to obtain information for the design of the well and surface gas and brine handling facilities. These facilities should be designed and long lead procurement should be initiated to allow construction and testing of the reservoir in FY92. At Pleasant Bayou, a one megawatt power plant has been installed, the first demonstration of electricity production from both the natural gas and the thermal energy in the hot brine. Operation and testing has begun, and will be completed during FY90. The well should then be tested at high flow rates for a prolonged period to yield information about the size and quality of the reservoir and the reservoir rocks. The Gladys McCall well has produced over 27 million barrels of hot brine and 675 million cubic feet of natural gas during the DOE test program, and is now ready for the final phase of testing. Understanding the changes that have occurred in the reservoir as a result of the testing is essential in predicting the economic potential of the entire resource.

To support this program, IGT recommends:

*** $9.6 million to continue the scientific data acquisition and analysis at the three geopressured/geothermal wells, Hulin, Pleasant Bayou and Gladys McCall, including design-related activities at Hulin, high flow rate testing at Pleasant Bayou, and core acquisition and testing at Gladys McCall.**

PRESSURIZED GASIFICATION OF REFUSE DERIVED FUELS:

IGT has developed a process called RENUGAS that will be an improvement beyond current municipal waste disposal technology. RENUGAS is a pressurized, fluidized-bed process for the gasification of biomass that can be applied to RDF. Gasifying RDF as part of a methanol synthesis and a combined cycle power plant will allow municipal wastes to be reduced in volume and converted to methanol and electricity in a highly efficient, environmentally sound manner.

In contrast to some municipal waste combustion systems, the closed gasification process offers total control over harmful emissions. RENUGAS will also produce more electricity, with efficiencies up to 45%, rather than the 32% characteristic of mass-burn steam cycles. This improved efficiency will not only make the plants more economical, but will also release 25% less CO2 for the same amount of electricity produced.

Finally, the flexibility of RENUGAS in methanol synthesis and combined cycle power plants makes it economic in a wide range of sizes and capacities, allowing its advantages to be gained by a broader range of communities and users beyond the primarily urban or regional facilities common for combustion systems.

To advance this technology, IGT recommends:

*** $1.0 million to begin a two-year program to apply the RENUGAS technology and IGT's existing process research unit to the production of methanol through the gasification of RDF.**

Madam Chairman, that concludes my testimony. I would be happy to answer any questions.

EASTERN OIL SHALE

While most oil shale research in this country has focused on Western oil shale, Eastern oil shale represents a significant resource that should not be overlooked in our effort to develop future domestic energy supplies.

The Institute of Gas Technology (IGT), using Fischer Assay results to measure potential oil production per ton of mined shale and U.S. Geological Survey mapping data, has estimated that 250 billion barrels of oil from Eastern shales are recoverable through surface mining. Because current Eastern shale technology produces oil yields up to 270% of the Fischer Assay results, the actual volume of recoverable oil is even larger.

Eastern oil shale is found in a band running from Alabama to Michigan and from Pennsylvania to Illinois, offering an oil resource close to markets and in a part of our country where mining, transportation and refining infrastructures are already in place.

Because Eastern oil shales are chemically different from their Western counterparts, retorting techniques specific to Eastern shales are being developed to produce oil at competitive prices. The chemical and retorting differences also allow Eastern shales to be processed without the of CO_2 release characteristic of Western shale processing. Western oil shales are made up of carbonate rocks which, when heated to processing temperatures, release CO_2. Eastern oil shales are silicates, which do not have that property.

Working under DOE contract, IGT has led a research team that has made significant advances in Eastern oil shale technology.

The IGT team has approached Eastern oil shale with a comprehensive program, addressing all aspects of the technology, including retorting, shale beneficiation and environmental impacts. They have developed a pressurized fluidized-bed hydroretorting (PFH) technology to increase the oil production from each ton of mined shale fed to the retort. Beneficiation technologies have lowered production costs by removing the inert material from the shale so that only the kerogen-laden portion of the rock is processed in the retort. The team has also addressed possible environmental impacts of shale processing and disposal of spent shale. Universities throughout the Eastern oil shale region have been actively involved in this research.

Although the price of Eastern shale oil is not yet competitive in crude oil markets, it compares favorably with Western shale oils and coal-derived synthetic oils. Continued commitment to bring the price of this vast resource even lower sends a strong price-cap signal to world energy markets.

To continue developing this resource, the IGT team proposes using its current facilities for research directed toward further lowering the cost of producing Eastern shale oil . This will be achieved by using proton conducting membranes to reduce the cost of hydrogen used in the process, upgrading raw shale oil with lower cost methane rather than hydrogen, and developing catalysts to improve the current PFH process. Work should also be done to further evaluate the quality and market potential of the oils and byproducts produced.

Eastern oil shale research is now at the stage where a process development unit capable of retorting one ton of beneficiated shale per hour is needed to move the PFH process toward demonstration and commercial scale. This scale-up will allow comprehensive testing of shales from Alabama, Kentucky and Ohio that represent the full range of Eastern oil shale characteristics. This program will provide oil, byproducts and spent shale in sufficient quantities to confirm the environmental compatibility of shale acquisition, processing and disposal, and test market applications of the oil and byproducts.

IGT recommends $4.35 million to initiate the scale-up of the PFH process to a one-ton/hour PFH process development unit, and $1.15 million to pursue further cost-effective improvements in the PFH process and evaluate the market qualities of the oils and byproducts produced.

DEMONSTRATION OF AN ADVANCED PROCESS FOR MILD GASIFICATION OF COAL

Although this country has 29% of the world's recoverable coal reserves, enough to last us well into the 22nd century, it currently supplies less than one-quarter of our national energy demands. Most of that current coal usage is limited to baseload electric power generation. Pending Clean Air legislation may limit our ability to expand our use of domestic coal to meet future energy needs.

The purpose of the Department of Energy's program in mild gasification of coal is to develop new, environmentally sound enhanced-value new fuel forms and condensible hydrocarbons from coal, creating new markets and demand for our coal resources.

In mild gasification, coal is heated to moderate temperatures and pressures to produce gaseous fuels, liquid hydrocarbons and solid char. The gaseous fuels are consumed within the mild gasification facility to provide the energy needed by the process, but the liquids and char, with lower sulfur content than coal, can be sold as products that have significantly higher market value than the original coal.

The char has potential uses in the production of form coke as a replacement for metalurgical coke in the steelmaking industry where there is a strong demand for environmentally acceptable alternatives for coke production, (it can also be used directly as a fuel or as a cost-competitive filter in water and waste water treatment.) The condensible hydrocarbons can be used as chemical feedstocks, and studies are underway to determine their value as a high energy density fuel for military applications.

Under DOE contract, the Institute of Gas Technology (IGT) heads a team of Peabody Holding Company, Inc., and Bechtel National, Inc., to develop an advanced mild gasification process capable of processing all U.S. coals. IGT has built and operated a 100 lb/hr process development unit, using innovative gasifier technology. That unit is currently being used to develop operating procedures that will maximize the yield of the value-added co-products. A market study has been performed which shows that there is good demand for the products that will be produced from the IGT process.

In order to further maximize the value of co-product production, studies should be performed to test coal blends to produce more usable chars and evaluate techniques for upgrading the liquid hydrocarbons. IGT's current facilities should be used for this work.

In FY90, the Congress directed funding to begin the construction of one 24 ton/day mild gasification process development unit. Selection of that technology is currently under consideration by DOE. In order to ensure that the mild gasification of a full range of domestic coals is demonstrated, it may be necessary to advance a second technology to this scale as well.

IGT recommends $8.5 million for mild gasification of coal, including $1.5 million for continued co-product research using IGT's current facilities, $4.0 million to continue the construction of the first PDU, and $3.0 million to initiate a second PDU if necessary.

NATURAL GAS SUPPLY: SECONDARY GAS RECOVERY/DEEP SEDIMENTARY BASINS

Natural gas is a clean burning, efficient fuel, for which demand is growing in the U.S. To increase our domestic supply, we should both recover as much of the gas present in known reservoirs as possible and identify new sources of natural gas.

As gas is produced from a field, some gas remains in the ground due to the geology of the reservoir and physical properties of the gas and reservoir rock.

One area for enhanced recovery not being currently investigated is the use of inexpensive inert gas to assist in natural gas recovery. This technology could be applied to all reservoirs, whether the gas pressure for production stems from a water drive or solely from the pressure of the gas in the reservoir. Use of this technique for water drive alone could provide increases of up to 50 TCF in our available reserves of low to moderate priced gas. The U.S. DOE, GRI and the gas industry are cofunding a program to look at methods other than inert gas to recover this gas. Primary gas production in fields with a strong water drive can leave as much as 50% to 70% of the original gas content trapped as water moves into the field to replace the withdrawn gas. Gas sweeping techniques, analogous to enhanced oil recovery, will use an inexpensive inert gas such as nitrogen or CO_2 to sweep the gas reservoir, either by pushing the remaining gas toward a recovery zone, while maintaining pressure and retarding water influx, or by displacing water which has blocked off pockets of gas. For non-water drive reservoirs, where the pressure in the reservoir decreases substantially as natural gas is produced, injection of an inert gas into the periphery of a reservoir will maintain production pressures, allowing more gas to be recovered at a lower overall average cost. For either type of reservoir, the effectiveness of this technique depends on limiting the degree of mixing between the inert gas and the natural gas being produced.

IGT is currently developing and field testing analytical and experimental tools to determine and limit the extent of mixing of inert gas and natural gas in underground natural gas storage systems. These same inert gas injection techniques can be applied to improving natural gas recovery from gas fields, allowing more complete recovery of known natural gas resources. The current DOE industry program should be expanded to include this approach.

Another untapped resource of new domestic gas supplies may be deep sedimentary basins.

Throughout the world, sedimentary basins are the major source of oil and gas, which is primarily produced from depths to 15,000 feet. Some of those basins extend down to 50,000 feet or more, and organic material capable of producing petroleum and natural gas has been deposited in strata throughout the depth of those basins. Because of the increase in temperature with depth, a greater amount of the organic material will be converted into oil and gas at greater depths. In the deepest parts of these sedimentary basins, the temperatures will accelerate the conversion of hydrocarbons to methane, creating the possibility of large quantities of natural gas. DOE estimates that as much as 195 TCF of methane might be producible from the 15,000 - 30,000 feet interval alone in deep sedimentary basins in the U.S., but reliable estimates of potential gas resources deeper than 30,000 feet do not yet exist.

The addition of significant amounts of gas from deep sedimentary basins to secure, domestic reserves is unlikely unless some basic research areas are investigated. Studies should be made to verify the presence of natural gas at those depths and to develop data to identify exploration and production targets for the future.

Along with determining the presence of natural gas at these depths, studies should be done on whether or not the rock at these depths has sufficient porosity and permeability to allow any methane present to flow to a well bore at rates sufficient for economic commercial recovery.

A program investigating the feasibility of producing methane from deep sedimentary basins must address these two criteria.

Through the DOE geopressured/geothermal and the GRI coproduction programs, IGT has developed laboratory and field expertise related to deep, water-driven gas/brine wells in deep sedimentary basins along the U.S. Gulf Coast. This knowledge and experience is directly applicable to investigating the presence of methane in deeper basins. IGT has also developed expertise and technology for determining rock porosity and permeability at stresses representative of deep in-situ conditions. Existing IGT equipment should be used as the base for determining rock properties under conditions representing 20-30,000 feet deep.

IGT recommends $1.75 million for a program to increase the natural gas supply in the U.S. by using inert gas injection to increase recovery of natural gas and for a program to investigate the feasibility of natural gas production from deep sedimentary basins in the US.

NATURAL GAS SUPPLY: SUBQUALITY GAS UPGRADING

The usable natural gas resource in the U.S. can be substantially increased if the subquality gas already discovered could be economically upgraded. The Gas Research Institute has estimated that up to 175 TCF of known domestic gas reserves are currently unusable because of the levels of carbon dioxide, nitrogen or hydrogen sulfide contamination. Technologies for the cost effective clean-up of these contaminants exist for large volume wells, but many smaller gas fields are shut in because the gas contains unacceptably high levels of these contaminants which currently cannot be economically removed at smaller scale.

Pressure swing adsorption (PSA) is a process commonly used to separate gases and, in the natural gas industry, it is one of the technologies used to remove unwanted contaminants from large volume natural gas sources. Heat is at various times either removed or added to the PSA process in order to accomplish the separation. If the adsorption could be made adiabatic, requiring no heat transfer into or out of the system, the separation should be simpler, more effective and more economic.

Under DOE contract, IGT has developed expertise in designing and manufacturing thermal energy storage materials. A thermal energy storage material tailored specifically to the temperature and heat release characteristics of a PSA separation system will, when added to the adsorbent bed, either take in or give off heat as required to maintain a constant temperature. This has the advantage of making the PSA process isothermal, occurring at a constant temperature, improving the efficiency and cost effectiveness of this approach. Use of the thermal energy storage material in a PSA process will simplify and reduce the size of equipment needed for PSA, thus improving the economics of natural gas production. That will allow the PSA process to be used in gas fields where it is currently not economically feasible. This process will be useful in other gas separations as well, not only in low quality gas upgrading.

Another technology for low quality gas upgrading that promises to be economic for small gas wells uses a microorganism discovered by IGT that can rapidly remove essentially all of the H_2S from low quality natural gas. IGT's microorganism uses the H_2S and the carbon dioxide frequently found in subquality gases to convert H_2S to solid, easily removable, elemental sulfur. Laboratory tests indicate that the speed and simplicity of this reaction should allow the design of equipment on a scale small enough for economic installations at small sour gas fields. Biological and engineering studies are necessary to determine the optimum approach for using a process based on this microorganism to bring this currently unusable gas to the market.

IGT recommends $0.75 million for the development of IGT's Isothermal Adiabatic Pressure Swing Adsorption (IAPSA) and microbial gas upgrading processes to upgrade subquality natural gas.

METHANE ENHANCED CHEMICAL SYNTHESIS

Methane is an inexpensive hydrocarbon that can also be produced from renewable resources. IGT has been developing novel approaches for using methane, including using it as an energy source in the biological production of unique, new high-value chemicals called single stereo isomers and as a reactant in converting petroleum-derived chemicals currently in oversupply into high-demand chemical feedstocks.

Stereo isomers are molecules which are chemically and geometrically the same but are paired as mirror images of each other. Each compound from a pair of stereo isomers behaves differently in biologic systems and has different chemical and physical properties than either its counterpart or a mixture of the two.

Until now, commercial production of single stereo isomers could only be achieved through expensive chemical or biological processes or by chemically producing the mixture of stereo isomers and performing costly separations to obtain a single isomer. This has precluded the use of single stereo isomers for other than limited volume medical and food ingredient applications.

The Institute of Gas Technology (IGT), with coordinated funding from the Gas Research Institute, has been investigating a biological co-oxidation process which produces single stereo isomers. IGT has discovered a microorganism which metabolizes methane, including sub-quality natural gas, to form an enzyme which can act as a catalyst to convert certain classes of chemicals into oxygenated single stereo isomers.

The ability to produce single stereo isomers in industrial quantities could lead to the creation of a broad range of new materials which have unique characteristics in such things as biodegradeability, strength, elasticity, biocompatability, optical clarity or electrical conductivity.

Another class of chemicals currently in great demand with predictions of extreme shortages is unsaturated hydrocarbons, a class of high-value petrochemicals used as intermediates to produce a wide range of products such as fuel additives and plastics. It is very expensive for the petroleum refining industry to increase production of these unsaturated hydrocarbons in sufficient supply to meet demand. The refining process also yields saturated hydrocarbons which, because of increasingly stringent clean air regulations, must be removed from gasoline. These saturated hydrocarbons are currently in excess supply and are used as fuels, an inefficient use of their chemical content.

Conversion of the saturated hydrocarbons into more useful unsaturated hydrocarbons will produce more unsaturated hydrocarbons from the same quantity of petroleum, extending our petroleum supplies while meeting the demand for unsaturated hydrocarbons.

IGT, with coordinated funding from the Gas Research Institute (GRI), has invented a proprietary catalyst and process for using methane to convert the abundant supply of saturated hydrocarbons into needed higher molecular weight unsaturated hydrocarbons.

The current IGT process accomplishes this reaction at atmospheric pressure and moderate temperature. Fundamental research on catalyst improvements, focusing on reducing the temperature, are needed to further improve this process and economically increase our supply of needed unsaturated hydrocarbons. DOE should initiate a program, coordinated with IGT and GRI, to accomplish these objectives.

IGT recommends $0.8 million to develop a biological process, using IGT's technique, to convert certain classes of chemicals into oxygenated single stereo isomers and to develop technology to convert saturated hydrocarbons into more valuable unsaturated hydrocarbons, thus expanding our chemical feedstock supplies.

MOLTEN CARBONATE FUEL CELL STACK PROGRAM

Fuel cells use electrochemical reactions to generate electricity directly from a hydrogen-rich gaseous fuel. Unlike gas turbines, they are highly efficient and quiet because there are no moving parts, and since there is no combustion, they produce only negligible emissions.

Fuel cells make use of a modular, stacked assembly, allowing great flexibility in sizes and applications, from a few hundred kilowatts to hundreds of megawatts, and from small, on-site natural gas fired cogeneration systems to coal gas fueled baseload utility power plants. They are also ideal for meeting incremental, decentralized power needs for domestic utilities, or for providing clean, efficient power in developing countries.

The molten carbonate fuel cell is an advanced fuel cell technology, improving on phosphoric acid fuel cells, with significant increases in over-all efficiency and cost-effectiveness. Molten carbonate fuel cells operate at higher temperatures than phosphoric acid cells, making them ideally suited for cogeneration applications.

Under the current DOE program, the Institute of Gas Technology (IGT) has developed and successfully demonstrated the IMHEX^R concept of molten carbonate fuel cell design, the only current U.S. approach using the advantages of internal manifolding to bring fuel and oxygen to the individual plates of each fuel cell stack. Internal manifolding of fuel cells, invented by IGT, gives advantages in ease of cell assembly, method of charging the electrolyte, carbonate management, and efficiency of cell sealing, all adding to the endurance and cost-effectiveness of the IMHEX^R approach. Because of these advantages, internal manifolding has also become the design of choice by Japanese and European fuel cell competitors. The M-C Power Corporation has been created to produce and commercialize fuel cells using IGT's IMHEX^R design.

The Department of Energy has been supporting the development of three separate approaches to molten carbonate fuel cell systems fueled by coal gas. At the direction of the Congress, the program for FY91 will be scaled back to continue full development of only two of those approaches, while the third current team will continue only with fuel cell stack research.

Over the past several years, DOE has been constrained to spent only about $15 million per year to support the three separate approaches to molten carbonate fuel cell development, which are scheduled for commercialization in the 1993-1995 timeframe. As commercialization nears, funding requirements for the total molten carbonate fuel cell program increase accordingly.

IGT recommends $30.0 million for the molten carbonate fuel cell program, divided among the three current development teams, to continue the full system development and scale-up of two of the current design approaches representing the broadest possible technical diversity, and continue stack research on the remaining design.

GEOPRESSURED/GEOTHERMAL METHANE

The DOE Geopressured/Geothermal program is directed toward solving the technical issues inhibiting the economic development of the huge U.S. geopressured/geothermal resource in the Gulf Coast area. These reservoirs consist of thousands of trillion cubic feet (TCF) of natural gas and a like amount of energy in hot brine.

In this program, brine and natural gas from these deep reservoirs are brought to the surface, the energy is extracted and the brine is re-injected into another saline aquifer.

The program's objectives include:

- improving the understanding of reservoir behavior,
- developing test procedures to determine reservoir capacity,
- developing hardware to resist the highly corrosive brine,
- demonstrating the reservoirs' ability to accept long term disposal of the spent brine,
- ensuring environmentally acceptable operation of both withdrawal and injection well systems,
- determining how to best utilize energy from this resource, and
- determining methods and hardware that will minimize fluid production costs.

This program requires the involvement of various organizations with expertise ranging from well operations, surface facilities and hybrid electric power plants to geology, physical chemistry, reservoir modelling, environmental studies and experimental data analysis.

Participating organizations include: Eaton Operating Company as the principal field contractor, Institute of Gas Technology, the Ben Holt Company, University of Texas at Austin, University of Southwest Louisiana, S-Cubed, Louisiana State University, Rice University, the Bureau of Economic Geology of the University of Texas at Austin and EG&G Idaho.

In addition, private industry is forming a coalition to coordinate potential uses of this resource. This group includes both major and independent oil companies, utilities and companies involved in food growing and processing, horticulture and aquaculture.

Three wells are included in this program: Gladys McCall (LA), Pleasant Bayou (TX) and Hulin (LA).

The Gladys McCall well has been extensively tested and has produced over 27 million barrels of hot brine and 675 million cubic feet of natural gas during the DOE test program. The flow-test program is now complete and the well is ready for the final phase of testing. This involves drilling sidetracks from the well into the reservoir, taking core samples, and comparing them with samples taken when the well was drilled to determine changes in rock properties. An understanding of the changes that have occurred in the reservoir as a result of the testing will provide a better understanding of this reservoir and will be useful in predicting the economic potential of the entire resource.

A one megawatt power plant has been installed at Pleasant Bayou and operation and testing has begun. This is the first demonstration of electricity production from both the natural gas and the thermal energy in the hot brine. Two thirds of the electricity is generated from a portion of the natural gas released from the brine, and one third from the thermal energy in the brine, using a turbine with an isobutane working fluid. This demonstration will be completed in FY 90. The well should then be tested at high flow rates for a prolonged period to yield information about the size and quality of the reservoir and the reservoir rocks.

The Hulin well is the deepest and hottest of the three wells, with a depth of 20,700 feet and bottom hole temperature of 340° F. This is the only test well that has the potential for free gas in addition to the gas dissolved in the brine. Due to budget constraints, this well was only operated for a short period of time in FY 90, using rented surface equipment to determine the suitability of the reservoir for long term testing. This short period of testing has shown that the reservoir merits the expense of long term, high flow rate well testing . In FY 91, more comprehensive testing is required to obtain information for the design of the well and surface gas and brine handling facilities. These facilities will be designed and long lead procurement will be initiated to allow construction and testing of the reservoir beginning in FY 92.

PRESSURIZED GASIFICATION OF REFUSE DERIVED FUELS

Even with the growing emphasis on recycling municipal solid wastes, communities throughout the country are rapidly running out of acceptable landfill space. Significant efforts have been made by many communities, even after recycling as much as possible, to further reduce the volume of their disposable wastes by burning the remaining refuse, either by simple incineration or by burning it in a waste-to-energy plant.

Many municipal waste combustion systems have improved their efficiency and material-handling reliability by first converting the bulk municipal waste to refuse derived fuel (RDF), sorting out the non-combustibles and processing the remainder into a consistent shredded or pelletized fuel.

Problems still remain, however. There is growing concern about the pollutants that may be emitted from municipal solid waste incinerators and waste-to-energy plants, and about the toxics created in those combustion processes.

The Institute of Gas Technology (IGT) has developed a process called RENUGAS that will be an improvement beyond current municipal waste disposal technology. RENUGAS is a pressurized, fluidized-bed process for the gasification of biomass that can be applied to RDF. Gasifying RDF as part of a methanol and higher alcohol synthesis and a combined cycle power plant will allow municipal wastes to be reduced in volume and converted to clean, oxygenated fuels and electricity in a highly efficient, environmentally sound manner.

Because of its low temperatures, the RENUGAS process does not produce the dioxins created in same municipal waste combustion systems, and the closed gasification process releases no harmful emissions. RENUGAS will also produce more electricity, with efficiencies up to 45% rather than the 32% characteristic of mass-burn steam cycles. This improved efficiency will not only make the plants more economical, but will also release 25% less CO2 for the same amount of electricity produced.

Finally, the flexibility of RENUGAS in alcohol fuel synthesis and combined cycle power plants makes it economic in a wide range of sizes and capacities, allowing its advantages to be gained by a broader range of communities and users beyond the primarily urban or regional facilities common for combustion systems.

IGT recommends $1.0 million to begin a two-year program to apply the RENUGAS technology and IGT's existing process research unit to the production of oxygenated fuels through the gasification of RDF.

Mr. **Bruce**. We thank you, Dr. Tarman, for your testimony, and Mr. Webb and Mr. McCastlain, also. I'd just like you to know that in my other Committee assignment, I serve with Billy Tauzin, and all of your testimony has been given by him more times than you would imagine in our clean air debate, so I've heard everything that you've said at least once already in my life. I appreciate it, and I don't know whether you have adopted him, but he certainly has adopted you.

Questions of this panel?

Mr. Smith.

Mr. **Smith**. Thank you, Mr. Chairman.

Mr. McCastlain, you estimated that current gas reserves would last about 58 years using current technology. What kind of length of time could we expect the reserves to last if we used some of the proposed technology that we might expect to be developed with the budget that you propose?

Mr. **McCastlain**. I don't have those answers readily available. I think Dr. Tarman or Mr. Webb may have that information, but certainly, as I briefly scan the DOE's gas implementation plan, they mentioned in the unconventional and speculative area tremendous amounts of gas and, of course, we need to have the technology out there to go find it and prove it.

Mr. **Smith**. Would you expect the price of natural gas to be competitive with other energy sources?

Mr. **McCastlain**. I would think so.

Mr. **Smith**. I'm trying to get you to make a pitch for natural gas here. What about the role of natural gas in the national energy strategy?

Mr. **McCastlain**. We're still getting our comments together on that. I might ask one of our attorneys.

Phyllis, do you have any remarks on the National Energy Strategy?

Ms. **Levine**. My name is Phyllis Levine. I'm an attorney with AGA. We did file comments on the NES on specifically a natural gas R&D aspect in February, and we are in the process of following up with kind of a short bullet type comment, and we are pleased that natural gas is playing a greater role now in DOE's policy than it used to.

We still feel that there are more areas where they can focus on, especially in the utilization area. Not so much supply, but the utilization area. They focus on just a few, co-firing, for one, which we are very pleased about, as I'm sure Mr. Chairman is, but we feel there are other areas where they can stress more. We'll be happy to give this Committee a copy of the comments we filed with DOE.

Mr. **Smith**. Okay, we appreciate that. Thank you.

[The information follows:]

POSITION OF THE AMERICAN GAS ASSOCIATION
SOUTHERN CALIFORNIA GAS COMPANY
THE GAS RESEARCH INSTITUTE
THE INSTITUTE OF GAS TECHNOLOGY
ON DOE'S INTERIM REPORT ON
THE NATIONAL ENERGY STRATEGY

Executive Summary on Research and Development Funding for Energy Efficiency and Air Quality

Description of the Issue: A comprehensive national energy policy must include the contribution that can come from highly efficient combustion technologies with very low levels of emissions, because of the positive impact these technologies can make toward reducing energy consumption and improving our nation's air quality. Fossil fuel combustion has been and is projected by DOE to continue to be the preferred way to power our economy for the next 20 years. If our nation's economy is to continue to grow, additional fossil fuel combustion will be required by energy consumers to power this growth. Yet even the most efficient and cleanest fossil fuel combustion today still creates emissions.

Increased use of natural gas in place of more polluting fossil fuels will help improve air quality in much of the nation. However, in the future, significant advances in reducing combustion emissions -- even from clean-burning natural gas -- will be required to enable a large number of metropolitan areas to meet federal clean air standards or to comply with state implementation plans as their local economies and, resultant emissions, grow.

Intensified research and development programs focused on improvement in air quality through highly efficient combustion technologies with very low levels of emissions should be considered a critical element of the National Energy Strategy.

The nation will benefit from increased research and development funding for natural gas air quality and utilization technologies because:

- this RD&D will result in technology to substitute natural gas for coal and oil or other petroleum products, thereby reducing the total amount of dirty and imported fossil fuels used;

- more efficient natural gas end-use technologies will yield virtually no adverse environmental impacts;

- this RD&D will also facilitate economic growth by enabling U.S. industry to compete in the global marketplace more effectively.

In order to maximize the benefits from using efficient, clean-burning natural gas, DOE must prioritize its funding initiatives in its Final National Energy Strategy by providing for programs on:

- Stationary Emission Solutions - Research into improved, highly efficient combustion processes, low NO_x burners and high heat transfer efficiency water heaters should lead to reduced emissions from stationary sources such as industrial boilers and residential space and water heaters. Programs should focus on using natural gas for emissions control, as in cofiring and reburn. In addition, programs should also focus on energy efficiency, as in advanced combined cycle gas turbines, steam-injected gas turbines, and intercooled steam-injected gas turbines.

- Mobile Emission Solutions - Development of dedicated natural gas vehicles could contribute to the substantial reduction in mobile source emissions that will be required to meet future Clean Air Act standards. Compressed natural gas (CNG) is much cleaner than conventional fuels but focused RD&D is needed to adapt vehicles for optimal performance and develop CNG storage and refueling technologies.

- Electrochemical Energy Conversion - Fuel cells can potentially produce electricity with less than 1% of the atmospheric contamination of conventional, fossil-fuel based electric generation. Accelerated development of second and third generation fuel cells will lead to highly efficient, virtually non-polluting, small-scale power plants that can be deployed on site, reducing the need for large electrical generating plants.

- Other Utilization Programs - The Advanced Research and Technology Development program that generally supports basic research in combustion chemistry, engineering concepts and materials and components needs to be pursued. The Energy Conversion and Utilization Technology (ECUT) program, which focuses on ceramics and other advanced materials, also needs to be continued.

To allow maximum balanced economic growth in large urban areas without violating future plans for maintaining national ambient air quality standards, the federal government must make a substantial commitment to funding research, development and demonstration (RD&D) programs geared to further improving energy efficiency and greatly reducing emissions resulting from fossil fuel use. In order to have these least cost energy options available for industrial, commercial and residential natural gas consumers, a DOE program funded at $150 million in fiscal year 1992 is necessary to provide for an accelerated RD&D program.

DOE has a program for the electric utility industry, the Clean Coal Demonstration program (a total of $2.5 billion), that is already producing benefits, in terms of improved efficiency and lower emissions, for the electric utility industry's utilization of coal. Balanced economic growth that maintains least cost energy choices for all energy consumers in many urban areas will also require development of highly efficient, very low emission combustion technologies for industrial, commercial and residential natural gas users.

In conclusion, we urge DOE to include in the National Energy Strategy options to the President, a commitment to increased RD&D funding to improve air quality through the development of highly efficient natural gas technologies with very low emissions.

POSITION OF THE AMERICAN-GAS ASSOCIATION ON DOE'S INTERIM REPORT ON THE NATIONAL ENERGY STRATEGY

Executive Summary on Funding for Natural Gas Supply Research and Development

Description of the Issue: Increased research, development and demonstration (RD&D) funding for all energy sectors is necessary to overcome the obstacles cited in the Interim Report. However, federal RD&D funding for natural gas activities has always fallen far short of the amount allocated for coal, nuclear and oil. Now is the time for DOE to prioritize its RD&D activities. By focusing its efforts on increased RD&D funds for natural gas supply activities, huge environmental, energy efficiency and energy security benefits will be attained.

The nation will benefit from increased research and development funding for natural gas supply technologies because:

- this RD&D will result in technology to substitute natural gas for coal and oil or other petroleum products, thereby reducing the total amount of dirty and imported fossil fuels used;
- natural gas related RD&D will allow for the more efficient development and use of a large domestic resource, thereby reducing our nation's reliance on foreign oil and refined products, and obviate the need for development of major foreign trade in other alternative fuels, such as methanol;
- this RD&D will also facilitate economic growth by enabling U.S. industry to compete in the global marketplace more effectively.

In order to maximize the benefits from using efficient, clean-burning natural gas, DOE must prioritize its funding initiatives in its Final National Energy Strategy by providing for programs on:

- unconventional natural gas supply, such as Devonian shales and tight sands, which are estimated to contain more than 1,800 Tcf and 900 Tcf of natural gas supply, respectively.
- underground coal gasification, which is estimated to be able to produce more than 1,000 Tcf of natural gas;
- surface coal gasification, which has the potential to contribute 100 Bcf of additional natural gas supplies;

- geopressured methane, which is estimated to contain up to 6,000 Tcf of natural gas; and,
- biofuels, which centers on research on suitable processing techniques to yield higher quality gas.

Mr. Chairman, I don't have any other questions.

Mr. BRUCE. Just for the panel, if you could just all give me your opinion as to the strengths and weaknesses of the gas research implementation plan. One of you covered that, but I just wonder, did the Department ask you any input on the implementation plan? If so, did they accept your recommendations? Did you make any recommendations that they did not accept that you would still like to see in the plan?

Mr. WEBB. Mr. Chairman, David Webb with the Gas Research Institute. We were provided a copy of the draft of the plan and asked for comments. We did give them comments. We were asked. Most of the comments that we provided were adopted.

Some of the comments we provided specifically were—the draft of the plan had no budgets, so without budgets you can't tell where the priorities are in their plan. We asked that they include budgets so we could determine where they were placing their priorities. There are budgets, I believe, in the plan that was submitted last week to Congress.

We recommended that they coordinate carefully with us and others in some of the activities, because heretofore the Department was in long-term R&D, now they're getting into near-term R&D; we don't have enough resources around to have duplication, so we asked them be sure and coordinate. The plan acknowledges the need to coordinate their program with the gas industry's program.

We also pointed out that we think the Government still has a viable role in some of the more long-term speculative resources and were pleased to see that in their base case, at least, they would continue to fund some of that work, and while that's longer-term post-2000, some of those speculative resources we could develop have tremendous qualities of natural gas.

Finally, we indicated that DOE should have a lead role in the environmental related issues, which are becoming more and more important, as you're aware, in the Clean Air Act. We think that the Federal Government has a viable role there, because sometimes you can't capture the economic incentive individually. It's a national benefit. Most of those recommendations were, in fact, included in their draft plan.

So where we are now, of course, is we would like to see funds provided for them to implement that program and then for us to sit down as industry and work out cooperative R&D ventures in the field applications parts of it, and then, of course, they would fund with universities, national labs, and whoever, the more basic research parts of it.

Mr. BRUCE. Mr. Tarman?

Dr. TARMAN. Yes, we have talked to staff members about some of the technologies that we are interested in working on and, in general, some of the other technologies that push the gas initiative. In the long run, from the natural gas point of view, we are mostly working and talking in the area of the geopressured geothermal.

Mr. BRUCE. I thank the panel.

Mr. Webb, just one follow-up question. You talked about the recoverable gas available. Under a DOE report issued in August of last year, they indicated about a 36-year known supply of natural gas using present recovery methods. That would vary greatly from the testimony that you gave this morning, but you used what we would call a "wiggle word" back in Illinois—you said under advanced recovery technologies. If those technologies were not to be developed, what is the known recoverable gas supply right now, in years?

Mr. **Webb**. Well, the actual reserves right now, if you're talking about what's out there behind the pipe that can be produced, it's a little less than 200 trillion cubic feet, so that's about nine to 10 years of supply. The gas that's known to exist that you think could be produced with current production is about another 200 trillion cubic feet, so another 10 years or so.

But DOE's own assessment, which is what I was using in my testimony, said that $3 to advanced technology is another 574 trillion cubic feet, so that's another 30 or so years, which means it's large enough that we ought to really get with it and develop it and use our domestic supplies to help solve some of these environmental problems and reduce our oil imports, sir.

Mr. **Bruce**. Okay, thank you.

Dr. Tarman, I wonder, the Department's budget for mild gasification activities, if it were adopted, it would restrict current as well as future efforts. You recommended additional dollars for research for mild gasification, including $4 million to construct the first PDU. Please describe that project and provide the cost estimates to complete it, and have you had any discussions about the PDU with the Department?

Dr. **Tarman**. Yes, we have had discussions. The program we're looking to on the PDU totals about $14.5 million. It would be cofunded by Peabody Coal Company, the State of Illinois, and Southern Illinois University. About 27 or 28 percent of the total funds would be provided by these other entities. DOE would then provide around 72 or 73 percent of the $14 million.

We're talking about a program that would start with the construction of the PDU and continue through the Fiscal Year 1992. At that time, we feel that we would have a situation where we would be ready for a commercial demonstration. That then could fit into possibly a clean coal initiative or some other type of initiative. At that time, we believe we will have shown that we will have an economic process and will be able to bring in even heavier, or more significant co-funding.

The process produces multi-products; therefore, we believe that because it produces multi-products, it has a more future economic potential. As one product goes up in value, you may be able to tilt the process slightly to make more of the more valuable product. So we feel it's very beneficial, has a high potential, but it does need a process development unit to prove it. We're doing it in a laboratory, and it has to be done on a larger scale now.

Mr. **Bruce**. The funding level will allow that project to go forward?

Dr. **Tarman**. Yes. Well, the current funding level?

Mr. **Bruce**. Yes.

Dr. **Tarman**. No, not the current funding level at DOE. The funding level I request will allow that program to go forward.

Mr. **Bruce**. There is a biding interest in my area, since that's in my district.

I appreciate the testimony of the panel. If there are no further questions, we appreciate your coming, and we will start with the next panel.

Our second panel consists of Dr. Frank Schora of the M-C Power Corporation and Dr. William Calkins from the American Chemical Association.

Dr. Schora, do you want to begin?

Dr. SCHORA. I can begin, sir, yes.

Mr. BRUCE. We've been starting from that end of the table. Since you're there, we'll just start with you.

Dr. SCHORA. Okay.

STATEMENT OF DR. FRANK C. SCHORA, PRESIDENT, M-C POWER CORP., CHICAGO, IL

Mr. SCHORA. Thank you, Mr. Chairman.

Mr. Chairman and Members of the Subcommittee, my name is Frank Schora. I'm President of M-C Power, and I'd like to inform you of the significant process that the M-C Power team, which includes, in addition to M-C Power, ABB Combustion Engineering and the Institute of Gas Technology, has made since my last testimony presented to this Subcommittee last year.

My testimony recommends $30 million for molten carbonate fuel cell development be included in the Fiscal Year 1991 authorization for the Department of Energy non-nuclear programs. The recommendation is for the work to be undertaken in response to DOE's recent PRDA for simulated coal gas molten carbonate fuel cell power plant system verification, with funding for two developers at a $12 million level for continued complete power plant system development and the third contractor at a $6 million level for stack development only.

I am pleased to report that the M-C Power team has been selected by DOE for complete power plant system development.

Mr. Chairman, M-C Power was established in 1987 with the sole objective of scaling up and commercializing the molten carbonate fuel cell. Early last year, we moved into a prototype manufacturing facility in Burr Ridge, Illinois.

Fuel cells hold a number of advantages over other electric power generating concepts. This especially holds true for the molten carbonate type, which, with up to 55 percent efficiency for coal-based and up to 62 percent efficiency for natural gas-based systems, have higher electrical generating efficiencies than other fuel cell types.

The molten carbonate fuel cell will be easy to manufacture and will be fabricated from relatively inexpensive materials, giving it a distinct cost advantage over the other types of electrical power generating devices.

The operating temperature of 1,200 degrees Fahrenheit will enable efficient use of waste heat and co-generation applications and for bottoming cycles in utility applications.

With the present phosphoric acid type fuel cell, which is now being offered for sale, such heat recovery is not possible. Power plants based on the molten carbonate fuel cell will exhibit superior environmental characteristics. The molten carbonate fuel cell will reduce SO_x by 99.95 percent and NO_x by 84 percent when used for repowering a conventional coal-based power plant.

If used in a new coal-based power plant, the anticipated 55 percent electrical power efficiency will result in a 40 to 45 percent reduction in both carbon dioxide emissions and fuel use compared to a conventional coal-fired plant. In applications using natural gas as fuel, there will be virtually no sulfur or NO_x emissions, and with the inherent high efficiency, reduction of carbon dioxide and fuel use will occur when compared to the alternate ways of producing electricity from natural gas.

With co-generation, applications are planned using the waste heat for producing high quality steam or directly for heating or air conditioning, increasing total system efficiencies to as high as 85 percent.

The M-C Power team has made significant progress since I testified before this Committee last year. To date, five tests have been completed on sub-scale fuel cell stacks of one square foot cell area. All have been successful and indicate that we have achieved a breakthrough in solving the carbonate pumping problem, which still plagues other approaches to molten carbonate fuel cell development.

Carbonate pumping, the movement of the carbonate electrolyte from one end of the stack to the other, will lead to premature stack failure, resulting in the stack falling short of the endurance needed for commercial acceptance.

This problem is inherent with the external manifoldes molten carbonate fuel cell stacks but is solved by the use of the internal manifolding, the basis for our IMHEX design.

No carbonate pumping has been detected in our five tests, and we understand that most of the foreign molten carbonate fuel cell developers are also using internal manifolding designs with the same results.

M-C Power is now in the process of scaling up our cell size to the full commercial size of approximately 10 square foot cross-sectional area. We believe this size will be sufficient for future commercial applications and will be cost effective. Our first full scale separator plates, which are the structural elements of the stack, separating one cell from the next, will be in manufacture shortly. In fact, the first plates are due for pressing next week.

We have pursued the pressing of separator plates from thin metal to minimize fuel cell stack fabrication costs and enable the eventual mass production of these stacks. This technique also reduces the amount of structural metal in the stack to one-third of that required in the old external manifolder designs, leading to additional lowering of costs.

M-C Power's Illinois manufacturing facility for producing the electrodes and electrolytes at full size will also be fully operable by the end of this month. We will be able to initiate assembling full scale stacks for testing shortly thereafter.

Our manufacturing facility is the largest and most modern molten carbonate fuel cell component fabrication plant in the world. At this time, we are producing electrode sheets which appear to be of very high quality. Components for the next stack test will be manufactured in these facilities rather than being produced in the laboratory, as they have been before.

In our overall plan, M–C Power will concentrate on the scale-up and manufacture of the IMHEX fuel cell stack. CE will engineer and fabricate the stack support systems and will eventually be the principal marketeer when the completed fuel cell system has been developed to the point of commercial readiness.

ABBCE is well-known by the electric utilities in the U.S. and the world and is familiar with the marketing approaches needed with the utility industry to achieve commercial acceptance. IGT, who has pioneered in the development of the molten carbonate fuel cell concept, will continue to support the team in an R&D mode to ensure that the necessary endurance is achieved.

At present, M–C Power, with our team of CE and IGT, is working under a DOE bridging contract until a Congressionally mandated down-selection is put into effect. Based on the evaluation of proposals submitted by the three current developers in response to the recent PRDA, it is my understanding that contracts will be awarded to two of the current contractors, M–C Power and ERC, for a continuation of full commercial efforts, while the third contractor, IFC, will continue to be funded for stack research only. I'm pleased to note that our team is cost-sharing about 32 percent of the cost of our particular program.

M–C Power believes that we can fully meet the objectives of the PRDA and intend to demonstrate a 250 kilowatt MCFC IMHEX system in California within the next 36-month program period. We are receiving enthusiastic reception for our program from both the utility industry and State government agencies.

We truly believe that our IMHEX internal manifold design is ready for a scale-up to full stack and systems. With adequate funding, we can successfully compete in the world market. Although M–C Power is asking for $12 million for Fiscal Year 1991, we anticipate requests for lesser amounts in the following two outyears, when cost-sharing by industry will become more significant.

Because our program is very tightly designed to meet the objectives at the lowest possible cost to the Government, we believe that a lower level of funding could slow our progress. We'd be pleased to have any Member of this Subcommittee or staff visit us in Burr Ridge to view what we're doing and to get a better feel for what molten carbonate fuel cell stacks and systems are.

I thank you for the opportunity to appear before you and will be pleased to answer any questions.

[The prepared statement of Dr. Schora follows:]

Testimony
Frank C. Schora, President
M-C Power Corporation
Before the
House Subcommittee on Energy Research and Development
June 20, 1990

Madam Chairman and Members of this Subcommittee, my name is Frank Schora. As president of M-C Power, I would like to inform you of the significant progress that the M-C Power team, which includes ABB Combustion Engineering (CE) and the Institute of Gas Technology (IGT), has made since my testimony presented to this subcommittee last year. This testimony recommends $30 million for molten carbonate fuel cell development be included in the FY91 Authorization for the Department of Energy non-nuclear programs. The recommendation is for work to be undertaken in response to DOE's recent PRDA for "Simulated Coal Gas Molten Carbonate Fuel Cell Power Plant System Verification" with funding for two developers at a $12 million level for continued complete power plant system development and the third contractor at a $6 million level for stack development only. I am pleased to report that the M-C Power team has been selected by DOE for complete power plant system development.

Madam Chairman, as you may remember, M-C Power was established in 1987 with the sole objective of scaling up and commercializing the molten carbonate fuel cell. Early last year we moved into prototype manufacturing facilities in Burr Ridge, Illinois.

Fuel cells hold a number of advantages over other electric power generating concepts. This especially holds true for molten carbonate fuel cells, which with up to 55% efficiency for coal based and up to 62% efficiency for natural gas based systems, have higher electrical generating efficiencies than other fuel cell types. The molten carbonate fuel cell will be easy to manufacture, and will be fabricated from relatively inexpensive materials, giving it a distinct cost advantage over other types of electric power generating devices. The operating temperature of 1200°F will enable efficient use of waste heat in cogeneration applications, and for bottoming cycles in utility applications. With the present phosphoric acid type fuel cell such heat recovery is not possible.

Power plants based on the molten carbonate fuel cell with exhibit superior environmental characteristics. The molten carbonate fuel cell with reduce SO_x by 99.95% and NO_x by 84% when used for repowering a conventional coal based power plant. If used in a new coal based power plant, the anticipated 55% electric power efficiency will result in a 40-45% reduction in both carbon dioxide emissions and fuel consumption compared to a conventional coal fired plant. In applications using natural gas as fuel, there will be virtually no sulfur or NO_x emissions, and with the inherent high efficiency, reduction of carbon dioxide and fuel use will occur when compared to alternate ways of producing electric power from natural gas. With cogeneration, applications are planned using the waste heat for producing high quality steam or directly for heating or air conditioning increasing total system efficiency to as high as 85%.

The M-C Power team has made significant progress since I testified before this subcommittee last year. To date, five tests have been completed on subscale fuel cell stacks of one square foot cell area. All have been successful and indicate that we have achieved a breakthrough in solving the carbonate pumping problem which still plagues other approaches to molten carbonate fuel cell development. Carbonate pumping, the movement of the carbonate electrolyte from one end of the stack to the other by wicking of the molten carbonate in the external manifold gasket, will lead to premature stack failure, resulting in the stack falling short of the endurance needed for commercial acceptance. This problem is inherent with external manifolded molten carbonate fuel cell stacks, but is solved by the use of internal manifolding, the basis for our IMHEX^R design. No carbonate pumping has been detected in our five tests and we understand that most of our foreign competitor molten carbonate fuel cell developers are also using internal manifolding designs with the same results.

M-C Power is now in the process of scaling up in cell size to the full commercial size of approximately 10 square feet. We believe this size will be sufficient for future commercial applications and will be cost effective. Our first full size separator plates, which are the structural elements of a stack, separating one cell from the next, will be in manufacture shortly. The first plates are due for pressing next week. We have pursued the pressing of separator plates from this metal to minimize fuel cell stack fabrication costs and enable the eventual mass production of fuel cell stacks. This technique also reduces the amount of structural metal in the stack to one third of that required in the older external manifold designs, leading to additional lowering of costs.

M-C Power Illinois manufacturing facility for producing the electrodes and electrolytes at full size will also be fully operable by the end of this month. We will be able to initiate assembling full scale stacks for testing shortly thereafter. Our manufacturing facility is the largest and most modern molten carbonate fuel cell component fabrication plant in the world. At this time we are producing electrode sheets which appear to be of high quality. Components for the next stack test woll be manufactured in these facilities rather than being produced in the laboratory.

In our overall plan M-C Power will concentrate on the scale-up and manufacture of the IMHEX^R fuel cell stack. CE will engineer and fabricate the stack support systems and will eventually be the principal marketer when the complete fuel cell system has been developed to the point of commercial readiness. CE is well known by the electric utilities in the U.S. and the world and is familiar with the marketing approaches needed with the utility industry to achieve commercial acceptance. IGT, who has pioneered in the development of the molten carbonate fuel cell concept, will continue to support the team in an R&D mode to ensure that the necessary endurance is achieved.

At present, M-C Power, with our team of CE and IGT, is working under a DOE bridging contract until a Congressionally mandated down-selection is put into effect. Based on the evaluation of proposals submitted by the three current developers in response to a recent PRDA, it is my understanding that contracts will be awarded to two of the current contractors, M-C Power and ERC, for a continuation of full commercialization efforts, while the third contractor, IFC, will continue to be funded for stack research only. I am pleased to note that our team is cost sharing about 32% of the cost of the program.

M-C Power believes that we can fully meet the objectives of the PRDA, and intend to demonstrate a 250 kW MCFC IMHEX^R system in California within the thirty-six month program period. We are receiving enthusiastic reception for our program from both the utility industry and state government agencies.

We truly believe that our IMHEX^R internal manifold design molten carbonate fuel cell is ready for scale up to full scale stacks and systems. With adequate funding, we can successfully compete in the world market. Although M-C Power is asking for $12 million for FY91, we anticipate requests for lesser amounts in the following two out years, when cost sharing by industry will become more significant. Because our program is very tightly designed to meet the objectives at the lowest possible rate to the government we believe that a lower level of funding could slow our progress.

I thank you for the opportunity to appear before this subcommittee and would be pleased to answer any questions.

Mr. **Bruce**. Thank you, Dr. Schora, for your testimony.

We will now hear from Dr. William Calkins of the American Chemical Society.

Dr. Calkins.

STATEMENT OF DR. WILLIAM H. CALKINS, CHAIRMAN, DIVISION OF FUEL CHEMISTRY, AMERICAN CHEMICAL SOCIETY, WASHINGTON, DC

Dr. **Calkins**. Mr. Chairman, my name is William Calkins. I am Chairman of the Division of Fuel Chemistry of the American Chemical Society and Adjunct Professor of Chemical Engineering at the University of Delaware.

The Fuel Chemistry Division consists of about 1,000 chemists and engineers whose primary interest is fuel research and development. The ACS Board of Directors has authorized my presentation of this statement of the Society's views regarding fossil energy research.

In brief, we feel increased, not less, research is needed and that the supply of trained fuel scientists and engineers is alarmingly low and that efforts should be made to rectify these problems. While we agree strongly with the studies that project a serious shortage of scientists and engineers and mathematicians later in this decade and the efforts that are underway in our Society and Departments of Energy and Education and other groups to try and rectify this problem, we feel that the shortage of trained fuel scientists and engineers is an even more imminent problem than is the general shortage of scientists and engineers.

Your Subcommittee is no doubt well aware that the United States is faced with a serious problem of energy supply, particularly of transportation fuels and heating oil. Last year, the U.S. imported more petroleum than it produced, and the domestic production of petroleum is dropping steadily. A substantial portion of our balance of trade deficit is attributable to imported oil, and the threat of cut off of petroleum imports, as occurred in 1973, still exists and may even be more serious since we've been unable to settle that peace situation.

At the same time, we're confronted with a number of serious environmental problems arising from the use of both petroleum and coal, which must be addressed. Steps have already been taken by the Congress with the clean coal technology initiative, and more stringent clean air legislation is proposed. Both of these initiatives will require a great deal of scientific and engineering R&D.

The United States is fortunate in being richly endowed with both coal and oil shale. Coal represents approximately 90 percent of our indigenous fossil energy and about a third of the world's coal resources. However, despite very encouraging advances in direct coal liquefaction technology and in shale processing, we still do not have economically viable processes for commercial exploitation of these enormous resources at present day oil prices.

Further improvements in our technology for coal liquefaction appear to be quite possible but will require continuing research. The solution to processing these resources economically and to associated environmental problems must come in large measure from fuel scientists and engineers.

In 1973, when the energy crisis hit, the United States had only a small cadre of trained scientists and engineers capable of dealing with the complex problems involved. It took six to 10 years to develop a sufficient number of trained people to attack the problems associated with the utilization of these materials.

Important progress was made in coal liquefaction, coal gasification, shale oil production, and in cleaning processes for fuels and gases. However, with the drop in imported oil prices, the energy industry, which had built up a large number of experienced fuel scientists and engineers, shut down some laboratories and drastically reduced staff across the industry.

This was done because there was little prospect of near term commercial exploitation of nonpetroleum fuels. While it was difficult to get accurate figures on the number of industrial researchers actively engaged in alternative fuel research, a fairly reliable measure of this can be obtained from the patent literature. We made a patent search that showed that industrial research on alternative fuels went through a maximum in the early 1980s and now has dropped to almost zero.

Discussion with a few companies willing to disclose their research efforts in this field amply confirmed the conclusion that such research has stopped in most energy companies. While industrial research effort has been drastically reduced, similar research in the national laboratories, research institutes and universities have also been greatly curtailed.

This decline in fossil energy research has resulted from reduction in both Federal and private funding. Declining research funds have also reduced the number of technical people actively engaged in fuel energy research and the number of new people being trained in the field.

Ample supply of clean fossil energy are vital to the well-being of the country and will be for decades to come. The United States finds itself in a precarious position. We are not only without an assured and environmentally benign fuel supply, but we also do not have the trained people to extricate ourselves from the next energy crisis if and when it comes.

Even if adequately trained people were available to do the work, development, design and construction would be required over a long period to establish plants for production of fuels from indigenous coal or oil shale sources. If people have to be recruited and trained, the time will be much longer.

Fuel scientists and engineers are the people capable of developing the technology for utilization of indigenous, that is, non-petroleum, fossil energy supplies. They also must play a major role in solving the difficult environmental problems associated with the use of these energy sources and with petroleum.

Therefore, the American Chemical Society strongly recommends that financial and other incentives be provided for industry so that indigenous petroleum supplies are conserved and long range research targeted for use of other indigenous fossil fuel resources is encouraged. The ACS also strongly urges that the advanced coal research programs in the fossil energy R&D budget be increased over the 1990 level by 50 percent and that the rest of the fossil energy budget be restored to 1990 levels.

This new budget would provide for an enhanced research effort in universities and in various Government-supported institutions. More importantly, it would provide for the training of more fuel scientists and engineers, which the United States so desperately needs.

I might add that I feel it would be disastrous to shut down the Wilsonville facility, which is the only sizable pilot facility we have for studying coal liquefaction, which is necessary to make the necessary improvements that are needed in order to get the cost of liquid fuels from coal down from $35 to $40 per barrel down to the $20 to $30 per barrel range that we need.

The ACS thanks you for the opportunity today to express its views, and I will be glad to answer any questions I can.

[The prepared statement of Dr. Calkins follows:]

STATEMENT

of the

American Chemical Society

STATEMENT

of

DR. WILLIAM H. CALKINS

on behalf of the

AMERICAN CHEMICAL SOCIETY

to the

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

on the

DEPARTMENT OF ENERGY FOSSIL R&D BUDGET

WEDNESDAY, JUNE 20, 1990

American Chemical Society • 1155 Sixteenth St., N.W. • Washington, D.C. 20036 • (202) 872-4466

Madam Chairman and Members of the Subcommittee:

My name is William Calkins. I am the Chairman of the Division of Fuel Chemistry of the American Chemical Society and Adjunct Professor of Chemical Engineering at the University of Delaware. The Fuel Chemistry Division consists of about 1,000 chemists and engineers whose primary interest is fossil fuel research and development. The ACS Board of Directors has authorized my presentation of this statement of the Society's views regarding the Department of Energy's fossil energy research budget; in particular, the alarmingly low number of trained fuel scientists and engineers in the United States.

Several recent reports[1,2] spell out difficult problems the United States is facing in ensuring an adequate energy supply and minimizing the environmental impact of fuels used in transportation, heating, and electricity generation. The distressing increase in the amount of petroleum being imported (now greater than the amount the U.S. is producing), air pollution from power plants, and the inability of many of our cities to attain present air quality standards are matters that affect the national security, economic strength, and quality of life of this Nation. The Department of Energy is currently developing a National Energy Strategy that will address many of these concerns.

Congress is to be commended for initiating the Clean Coal Technology[3] Program in 1986, which is clearly a valuable first step toward reduction of air pollution from power plants. Further steps will be required to deal with the supply and pollution problems resulting from the use of transportation fuels. The "greenhouse effect," still a matter of debate among scientists, also may require special measures.

The American Chemical Society draws your attention to a related situation having serious implications for this Nation, specifically the development and maintenance of a sufficient number of scientists and engineers who are trained and knowledgeable in the particular problems involved in fossil fuel technology.

At the time of the "energy crisis" of 1973, the United States had only a very small cadre of trained scientists and engineers capable of understanding the technologies and performing the research and development work required. Scientists and engineers working in fossil energy are employed in industry, government

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[1] U.S. Production of Liquid Transportation Fuels: Costs, Issues, and Research and Development Directions, National Research Council (Washington, D.C., 1989)

[2] Energy Security, Department of Energy Report to the President (Washington, D.C., 1987)

[3] In a previous statement, the ACS recommended that a portion of Clean Coal Technology funds be set aside for fundamental R&D to provide a better understanding of the complex phenomena involved.

laboratories, and research institutes, as well as in a limited number of universities. It took the next 6 to 10 years to develop sufficient numbers of experienced people in these institutions to deal with the problems involved.

In those years, the numbers of industrial scientists and engineers actively working on these problems increased greatly. Pilot plants for demonstration of processes for liquefaction of coal (which represents about 90 percent of our indigenous fossil energy resources) were built and operated. These activities led to the development of a process for direct liquefaction of coal to produce liquid fuels for transportation and heating. This process is a vast improvement over older German and more recent U.S. processes. It is estimated to be capable of producing transportation fuels at a price reached by imported petroleum in 1984. Promising avenues exist for reducing these costs further with additional research and development. Also, new coal gasification processes were demonstrated, oil shale retorting and shale oil refining processes were tested, and a number of alternative processes were developed to alleviate air pollution arising from coal combustion.

With the drop in oil prices, and the consequent removal of incentives for near-term commercial exploitation, several industrial laboratories were shut down and technical staffs across the industry were drastically reduced. A search of those U.S. patents filed in coal liquefaction, coal gasification, and shale oil processes, for example, clearly shows the result. Patents in these fields filed in this country by U.S. organizations increased steadily from 1973 to a maximum in the early 1980's, and dropped almost to zero by 1989, despite many remaining problems that need to be solved. While the free enterprise system clearly has served this country well, current market forces and uncertainties in forecasting provide no incentives and involve too many risks for industry to actively pursue projects needed in the long term.

Similar problems, although somewhat less severe, exist at the national laboratories. For example, at Argonne National Laboratory and Oak Ridge National Laboratory, key laboratories for energy research, funding for fossil energy research peaked in the early 1980's, and has since dropped 45 and 70 percent, respectively. The funding levels are reflected directly in the number of scientists and engineers actively engaged in fossil research at these laboratories.

The universities have diverted their attention to areas of chemistry and engineering more actively supported by other agencies. A history of fossil energy research at two of the major universities traditionally active in fossil fuel research--Pennsylvania State University and the University of Utah--is indicative of the problem being faced today. The graduate student population working on fossil energy problems has dropped about 35-40 percent since 1981-1982. An even more serious situation applies to those universities with smaller, but active, fossil energy programs. Many of these latter institutions have experienced greater difficulty in maintaining research programs. It should be noted that the Department of Energy's University Coal Research subprogram can only fund about 10 percent or less of the proposals received. Academic research programs are not only important for progress in the field, but also are needed to train the scientists and engineers of the future. Trained people lost to other fields of science or technology cannot easily be either replaced or returned to their original fields.

Ample supplies of clean fossil energy are vital to the well-being of this country. The United States finds itself in a precarious position--not only are we without an assured and environmentally benign fuel supply (despite our rich resources of coal and oil shale), but we also do not have the trained people to extricate ourselves from the next energy crisis. Even if adequately trained people would be available to do the work, long periods of development, design, and construction would be required to establish plants for production of fuels from indigenous sources.

Steps must be taken now to correct this critical situation. The solution can only be arrived at by increasing fossil energy R&D conducted in industry, government, university, and other laboratories. Fuel scientists and engineers are the only ones capable of developing the technology for utilization of indigenous fossil energy supplies. They also must play a major role in solving the difficult environmental problems associated with the use of these energy sources, as well as with imported petroleum. The American Chemical Society recommends that financial and other incentives be provided for industry so that indigenous petroleum supplies are conserved and long-range research targeted to use of other indigenous fossil fuel resources is encouraged.

The Society believes that the DOE's FY 1991 budget request for Advanced Coal Research programs, if implemented as is, would be disastrous. Even a level budget adjusted for inflation for FY 1991 would not be sufficient for the Nation to address the many problems referred to earlier or to provide the needed increases in trained scientists and engineers. The ACS strongly urges that the Advanced Coal Research programs in the Fossil Energy R&D budget be increased by at least $21 million to $62 million, about 50 percent higher than the FY 1990 budget levels. This represents an increase of about $28 million above the FY 1991 budget request. The accompanying Appendix gives a budgetary history for Advanced Coal Research programs (Advanced Research and Technology Development, Control Technology and Coal Preparation Advanced Research, Coal Liquefaction Advanced Research, Combustion Systems Advanced Research, Fuel Cells Advanced Research, and Surface Coal Gasification Advanced Research).

The American Chemical Society appreciates this opportunity to express its views. The Society hopes that you will consider these concerns and recommendations as you take up the Fossil Energy R&D budget for FY 1991.

Appendix

ACS
June 20, 1990

APPENDIX

Federal Support for Advanced Coal Research Programs (a)

(Dollars in Thousands)

	Control Technology & Coal Preparation Advanced Research	Advanced Research & Technology Development	Coal Liquefaction Advanced Research	Combustion Systems Advanced Research	Fuel Cells Advanced Research	Surface Coal Gasification Advanced Research	TOTAL
1981		$58,383					$58,383
1982		51,936					51,936
1983		31,650					31,650
1984		38,996					38,996
1985		30,804	$5,511			$3,364	39,679
1986		33,849	5,157			3,379	42,385
1987	$1,139	26,630	4,470	$3,248	$1,350	2,806	39,643
1988	2,042	24,937	6,132	3,351	1,547	2,698	40,707
1989	1,774	25,564	6,902	2,972	1,597	2,679	41,488
1990	2,092	26,390	6,636	2,360	1,458	2,617	41,553
1991(b)	1,659	26,488	2,890	2,159	352	546	34,094

a. Until 1986, Coal Liquefaction Advanced Research and Surface Coal Gasification Advanced Research were funded under Advanced Research and Technology Development as the Processes subprogram. Part of the Direct Utilization subprogram under AR&TD was transferred to Advanced Research within Control Technology and Coal Preparation, Combustion Systems, and Fuel Cells to comply with FY 1988 Congressional direction.

b. Administration's Budget Request.

Source: Budget Justification Books for the Department of Energy.

Mr. **Bruce**. Dr. Calkins, I appreciate your concern about the need to have trained scientists and engineers in fossil fuel technology, and your concern is shared by many of the Members of this Subcommittee and Members of Congress, in general. I wonder, what financial incentives do you see that would be necessary to attract people into that particular profession? You mentioned in your testimony that you're at the University of Delaware?

Dr. **Calkins**. Yes.

Mr. **Bruce**. What do we need to attract students in your area into that curriculum?

Dr. **Calkins**. Well, as an example, every year we have this university support program of fossil energy. Approximately 300 proposals are received every year, and approximately 30 are funded. It becomes very discouraging for a professor writing a proposal to get a research grant and only having a roughly 10 percent chance of success, and we face that in other areas of funding as well, besides that university support program.

So funding universities is important, but funding other research institutions that are doing fuel research is also necessary to provide the job opportunities for the graduates that we produce to continue to work in their area. And if they don't continue to work in fossil fuel, they go into other things, and their expertise is lost.

Mr. **Bruce**. How many students are you working with in this particular area?

Dr. **Calkins**. Of fossil energy?

Dr. **Bruce**. Fossil energy.

Dr. **Calkins**. I would say we have something on the order of 20 graduate students. This is out of the air. Roughly 20 graduate students that are actually working in such areas as coal liquefaction and indirect liquefaction and so forth.

Mr. **Bruce**. Dr. Schora, I appreciate your testimony, and I'm certainly pleased to hear about the progress you're making on the molten carbonate technology. How many years do you think it will be before this project is completed? In your testimony, you said you were looking forward to scaling up to a 10 square foot cross-section model, but I don't believe I heard you say when you were going to do that.

Dr. **Schora**. Well, the objective of the PRDA is basically to put a 250 kilowatt stack, which would consist of multiple cells of 10 square foot, into operation in a support system and to place this in a refinery, in fact, in the L.A. area. In our overall plans, we're looking to produce 250 kilowatt units or slightly larger units for use in industry and by the utilities by the mid-1990s.

Mr. **Bruce**. The 1990s. Has any particular refinery or utility company contacted you or have you contacted them?

Dr. **Schora**. Right now, we're finishing negotiations with Unocal in California for the site for the demonstration for this PRDA. SOCAL Gas will participate in that, and also the South Coast Air Quality District will participate. We're also, in fact, today working with the San Diego Gas and Electric for the possible siting of another demonstration unit, totally natural gas-based, in the San Diego area.

There is a desire by the people that we have involved, ABBCE, to see these units at commercial size as soon as possible, because they view a very large market for this type of device. In fact, they're seeing how we, in fact, can shorten the time period from, say, 1995–1996 to the 1994-1995 time period, and we're looking at that seriously.

Mr. BRUCE. Very good. I know you know in the budget DOE has only requested $7 million for all fuel cell research. I don't know whether you were here when they testified, in a lot of their programs, they expect to stretch out and not do any requests in Fiscal Year 1991. What impacts would that have on your research if we stood at the $7 million figure for all fuel cell research?

Dr. SCHORA. Well, it basically would mean that the proposals that were prepared and the work proposed under this PRDA put out by the Government in effect would not even be functional. At that level, with two people working toward a pre-commercial facility in a three-year period of time, and with another person working just on stack research, the funding would be relatively meaningless, and I think we'd lose our very large support from industry on the basis that they're rather confused as to what the Government's intent is.

Mr. BRUCE. I thank the panel.

Dr. CALKINS. May I make one more comment?

Mr. BRUCE. Absolutely, Dr. Calkins. Please do.

Dr. CALKINS. I think that one of the indications of the fact that the level of scientific personnel working in the field of fuel research has dropped so drastically is shown by attendance at various scientific conferences and also membership in scientific societies related to fuel research.

I happen to be very interested in the Gordon Research Conferences, which is kind of the premium research conference in fuel science that's held every other year. There was a period in 1981 when we were turning people away at 150, because that's the maximum capacity of those conferences. We're now having difficulty getting 80.

This is because the number of people that are actively working in this field has dropped so low that it just indicates the level of effort that is going on not only in universities, but also in industry as well, and I think that this is a serious situation for the country.

Mr. BRUCE. Thank you. Many of us have that same concern that without the scientists to make this research happen, you're not going to do it. I mean, that's the problem. We just won't do any of it.

We thank the panel for your enlightening testimony and appreciate your attendance.

Mr. MORRISON [assuming chair]. I'd like to invite up panel number three at this point. We're changing panels at the podium, also.

Panel three will be Dr. Frank Derbyshire, University of Kentucky; Dr. Joel Muehlhauser, University of Tennessee Space Institute; and Mr. Raymond Zahradnik, Occidental Oil Shale, Incorporated, from Colorado.

Gentlemen, let's proceed in the order that you are listed. As you have heard previously, your full statements will be made a part of the record, and we look forward to your testimony.

Dr. Derbyshire.

STATEMENT OF DR. FRANK DERBYSHIRE, DIRECTOR, CENTER FOR APPLIED ENERGY RESEARCH, UNIVERSITY OF KENTUCKY, LEXINGTON, KY

Dr. **Derbyshire**. Good morning, Mr. Chairman, Members of the Subcommittee. My name is Frank Derbyshire, I'm the Director of the University of Kentucky's Center for Applied Energy Research.

My testimony is in request of continuing financial support for research and development in eastern oil shale. Specifically, we are asking for a total of $8.5 million for eastern oil shale for fiscal year 1991, and this includes $4.35 million for the scale-up of the retorting technology being developed by the Institute of Gas Technology. This program will involve several universities in the eastern oil shale States. The request includes $1.15 million for further development of this process.

Also included is $375,000 for continued development of the technology known as KENTORT II at the University of Kentucky Center for Applied Energy Research, and this involves a scaling up from five pounds per hour to 50 pounds per hour of the retorting technology, which I shall be describing briefly.

The overall program has been agreed with DOE, and we'll begin using funds appropriated in the present financial year, as soon as these are released. Lastly, we request $380,000 for environmental research on retorted oil shale.

In support of these requests, I would like to provide some information about eastern oil shale. The eastern shale deposits are located in the States of Kentucky, Ohio, Alabama, Tennessee, and Indiana. Both the eastern and western deposits are very large reserves and important future sources of fuels and chemicals.

Over the last 10 years, a considerable effort has been expended in research and development of eastern oil shale, with financial support provided by—and I'll list these—the U.S. Department of Energy, individual State governments, and private industry, namely, Phillips Petroleum, the Mobil Foundation, Cleveland-Cliffs Research Foundation, Chevron Oil Company, and Breckenridge Minerals.

To illustrate the level of commitment, the State of Kentucky alone has invested over $5 million in this research, and all of our efforts have been cost-shared by the State. The activities in this research have been carried out by a number of universities, those in the oil shale States and also by universities in Illinois, Pennsylvania and Michigan, and, in addition, by private industry and other organizations amongst which I would note the Institute of Gas Technology, which has been prominent in providing much of the leadership in this area.

Over the last decade, we have acquired a great deal of improved understanding of eastern oil shale and how to develop it. Prior to 1980, eastern oil shale was considered to be a lean resource with limited economic potential. This was primarily due to reliance on the Fischer Assay method of estimating oil yield, and this method shows that compared to western shale eastern oil shale will produce only one-half of the yield of oil per unit of carbon.

Essentially, the Fischer Assay, being a laboratory test, does not predict the oil yields attainable by specific process technologies, and we now know this to be misleading. One of the most important milestones in this work was the recognition that the process technologies being developed for western shale are quite unsuitable for eastern shale, with the result that we've had to develop alternative process technologies.

Two appropriate technologies are being developed, both by ourselves and the Institute of Gas Technology, and in both cases these produce oil yields greatly in excess of the Fischer Assay. Speaking for our technology, KENTORT II, we have developed a concept which employs three integrated fluidized bed reactors.

Without going into detail of the configuration of this process, what we achieve by this system is a high oil yield, a high hydrogen-rich gas for use as a fuel or chemical feed stock, the recovery of sulfur as a valuable byproduct instead of its release as a pollutant, and a spent shale with little residual carbon or sulfur, which will certainly minimize the environmental problems in disposing of the spent shale.

A further relevant fact is that the eastern oil shale rock is primarily silicate, whereas that associated with much of the western shale is carbonate. During retorting, the carbonate rocks can decompose to release carbon dioxide, which, we're all aware, is a greenhouse gas, and this is not a problem to anything like the same extent with eastern shale.

There have also been significant improvements in process economics. A recent study by Foster Wheeler Corporation and the United States Department of Energy found that, using a technology similar to our, eastern oil shale can be produced at a cost of around $35 per barrel. This is almost $2 per barrel cheaper than the most economic scenario for western shale, and it's on the same order as currently projected costs of producing liquids from coal.

Other factors which are relevant to the development of eastern shale are that the necessary infrastructure and the markets for oil shale products already exist in the east. Labor is available for mining and processing, and there is a need to bring employment to these regions. Eastern shale could also be surface mined, which minimizes environmental disruption and facilitates land restoration.

A further relevant topic is that even with the items I've described and with a decade of research behind us, misunderstandings and prejudices relevant to eastern oil shale still persist. An example of this can be found in the National Research Council's report, Fuels to Drive our Future, which makes important recommendations for future energy research priorities. It also recommends that western U.S. oil shale should have high funding priority and eastern U.S. oil shale a low one.

The justification for this recommendation is, and I quote, "Eastern oil shale is low grade, occurs in thin seams, has a high stripping ratio for mining, and is inherently more expensive than western shale." I've already mentioned the economics of the two types of shale, and none of the other assertions are correct.

Eastern oil shale is not a low grade resource. The energy equivalence of eastern and western oil shale are almost the same. The claim that eastern oil shale occurs in thin seams is not correct. Most western oil shale must be mined underground, which limits recovery. Fifty percent recovery of 100 foot thick strata in the west is equivalent to total recovery of a 50 foot strata in the east, which is approximately the thickness of oil shale deposits in East Central Kentucky.

The claim that eastern oil shale has a high stripping ratio is also incorrect. For many reserves, at least, in oil shale, the ratio is less than 2.5 to 1, and Kentucky oil shale actually outcrops in some areas, where, of course, the stripping ratio is zero.

In addition, the report estimates the size of the eastern U.S. oil shale resource at 65 billion barrels. This is almost an order of magnitude less than that estimated by the United States Geological Survey and other research organizations, where they quote or report, "over 400 billion barrels of oil shale with another possible 2,600 billion barrels of shale from the extension of known deposits."

I would also like to point out that the National Research Council panel for this study did not include anyone with a background or experience in eastern oil shale research and development, and the only cited reference on the nature of the eastern oil shale's resource is an article from the Encyclopedia Britannica.

As well as containing erroneous facts about the eastern resource, the report also fails to take into account the major technological advances which I've described and which have been made in eastern oil shale through the support of this committee. The committee will be aware that there is a body of opinion which advocates channeling all oil shale funds into a single demonstration project for western shale. We don't feel that this is warranted by the current state of development of either technologies and feel instead that both resources merit funding in a balanced manner.

To recapitulate, we are requesting support for a total of $8.5 million for eastern oil shale research and development. Thank you.

[The prepared statement of Dr. Derbyshire follows:]

Testimony on Eastern Oil Shale Research
Energy Research and Development Subcommittee
House Committee on Science, Space and Technology

By

Dr. Frank Derbyshire, Director
University of Kentucky, Center for Applied Energy Research
3572 Iron Works Pike, Lexington, KY 40511

My testimony addresses the Department of Energy's non-nuclear research and development appropriations. In particular, I would like to present to the subcommittee considerations which support the continuance of research and development of Eastern U.S. oil shale for a total of $8.5 million dollars for the Fiscal Year 1991.

The Eastern Oil Shale Resource.

Eastern oil shale is a major energy resource that will play a substantial role in meeting the energy and chemical feedstock needs of the nation throughout the next century. In a study of this resource the U.S. Geological Survey found shale representing over 400 billion barrels of oil as measured by the Fischer Assay method, with another possible 2600 billion barrels of shale from extension of known deposits.[a] Of course the resource cannot all be recovered. However, even considering only the richest and most easily accessible shale, the resource is still enormous. For example, we conducted an intensive resource assessment of the shale in Kentucky considering only very rich shale that can be surface mined at very low stripping ratios and determined in place over 16 billion barrels of recoverable oil shale.[b] The recoverable oil will be much higher using recently developed technologies which can produce oil above Fischer Assay.

Research Progress Over the Past 10 Years.

Prior to about 1980, Eastern oil shale was considered a "lean" resource with limited economic potential. This was due to the reliance on the Fischer Assay, which shows that Eastern oil shale will produce about half of the oil per unit of organic carbon compared to Western U.S. oil shales. However, the Fischer Assay is a laboratory test and does not estimate the actual oil yield obtainable by a specific technology.

Substantial progress has been made over the past ten years in our understanding of the physical and chemical nature of Eastern oil shale. This has been a result of an intensive research program carried out by the U.S. Department of Energy; agencies of state government, including the Kentucky Energy Cabinet and state geological surveys; universities in Kentucky, Ohio, Indiana, Tennessee, Alabama, Michigan, Illinois and Pennsylvania; and private interests such as Phillips Petroleum, Southern Pacific Petroleum Companies and the Institute of Gas Technology. The latter organization has provided much of the leadership for the Eastern oil shale research effort over the past decade.

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[a] Duncan, D.C. and V.E. Swanson, U.S. Geological Survey Circular 523 (1965).

[b] Barron, L. et. al, Proceedings, 1986 Eastern Oil Shale Symposium, Institute for Mining and Minerals Research, University of Kentucky, Lexington, KY, p. 333 (1986).

The Commonwealth of Kentucky has played a major role in supporting and funding this effort. For example, we have spent over $1.3 million for pilot plant studies and well in excess of $4 million dollars in our University laboratories, such as the Center for Applied Energy Research (CAER) for a total of more than $5.3 million in State funds. The State support has been added to by private interests. The University of Kentucky has received almost a half million dollars in grants from organizations such as Phillips Petroleum, the Mobil Foundation, Cleveland-Cliffs Research Foundation, Chevron Oil Company and Breckinridge Minerals, Inc. The U.S. Department of Energy has also supported the State effort by matching almost dollar for dollar.

The University of Kentucky is one of the hosts of the Eastern Oil Shale Symposium, which has chronicled the level of research expended in understanding this resource. The tenth meeting will be held this November and to date over 400 technical papers have been presented and published in the symposium proceedings.

As a result of this research we have learned that the chemistry of Eastern oil shale is different from that of the Western U.S. The organic matter or "kerogen" which is the source of the oil is more like that of the oil shales of Brazil, Israel and Morocco. For example, the temperature required to attain maximum oil yield is higher and the shale oil must be collected differently to obtain optimum yields and maximize process economics. This is also why the Fischer Assay does not accurately measure the oil yield potential of Eastern oil shale and why the processing conditions designed for Western U.S. oil shale are inadequate for Eastern oil shale.

This fundamental research has lead to the development of new technologies, tailored to the unique characteristics of Eastern oil shale. These technologies are capable of producing higher than Fischer Assay oil yields; utilize almost the entire energy value of the resource; and can deliver additional products, such as sulfur, ammonia, urea, high-Btu gas, condensable hydrocarbons such as butane, and methanol precursors.

The CAER, in partnership with the U.S.DOE, is the developer of the KENTORT II technology. KENTORT II is a multi-staged fluidized bed retorting system which operates at atmospheric pressure and is capable of producing oil from Eastern shale at yields well above Fischer Assay. KENTORT II takes the residual carbon which does not convert directly into oil and gasifies it in a second integrated fluid bed stage. Here a medium-Btu hydrogen-rich gas is produced which can be processed into methanol or used to upgrade the shale oil. It is here also that most of the sulfur is removed as a hydrogen sulfide gas and can later be processed to elemental sulfur, a valuable by-product. A third fluidized bed combusts the shale to provide heat for the process.

KENTORT II was been designed from its inception to have outstanding environmental performance. The abatement of pollutants, primarily sulfur, is engineered directly into the reactor design instead of being relegated to downstream scrubbing systems. Turning a pollutant into a saleable by-product is inherently cost effective. The removal of sulfur in the retort also avoids problems with acid generation from the disposal of spent shale, facilitating reclamation of the mined lands.

We have completed a three year study of the KENTORT II technology in a 5-lb/hr system and confirmed the feasibility of the concept. We are currently in negotiation with the U.S. DOE to begin a second phase effort to build a retort which will process 50-lbs/hr. This system will utilize the process conditions of a commercial configuration. Sufficient products will be produced for meaningful appraisals of their quality and marketability.

Ours is not the only technology which has been developed in recent years. For example, using quite a different approach, the Institute of Gas Technology of Chicago, Illinois has pioneered a fluidized bed reactor which operates under pressure and is capable of producing oil at yields of two to three times that of Fischer Assay.

Eastern oil shale research has not been limited to process development. We have conducted extensive environmental research into the elemental leaching, geotechnical and reclamation characteristics of retorted Eastern shales and related materials. We are currently developing, with a group at the University of Wyoming, a large environmental study of the characteristics of the retorted shales produced by these new technologies.

Misconceptions About Eastern Oil Shale.

Although research progress has greatly increased our understanding of the nature of the resource and how to process it, many misunderstandings and prejudices appear to remain. An example of this can be found in the National Research Council's Report, *Fuels to Drive Our Future*, which makes recommendations for energy research for the coming decades. This report recommends that Western U.S. oil shale should have a high funding priority and Eastern U.S. oil shale a low priority. The justification for this recommendation is,

> "Eastern oil shale is low grade, occurs in thin seams, has a high stripping ratio for mining and is inherently more expensive than Western shale."

These assertions are not correct.[c] Yet the only evidence cited is a article in the *Encyclopedia of Britannica*! In addition, this report estimates the size of the Eastern U.S. oil shale resource as 65 Billion barrels, which is almost an order of magnitude less than that estimated by the United States Geological Survey[a] and other research organizations. I would also like to point out that the National Research Council panel for this study did not include anyone with a background or experience in Eastern oil shale research and development.

The Economics of Eastern Oil Shale Development.

Research progress means little if we do not reduce the costs of producing energy from the resource and this has been achieved. An intensive economic study performed by the Foster Wheeler Corporation and the United States Department of Energy was completed in 1989.[d] This study found that Eastern oil shale could be economically produced at a cost of $34.96 per barrel, using a retorting technology similar to KENTORT II. This is 50 to 80% lower than 10 years ago and there is still much room for improvement. ***The study also concluded that Eastern shale oil could be produced for $1.87 a barrel less that the least expensive Western shale oil scenario.***

There are other economic, social and environmental factors which favor Eastern oil shale development. I will mention some of them.

Infrastructure Costs. Sufficient infrastructure in the form of roads, utilities, water supply and waste treatment are already present in the East. The additional cost to develop the necessary infrastructure is not often considered and is a major factor in the economics of oil shale development.

Product Marketability. Eastern oil shale is located in proximity to where its products can be used. Three of the largest gas transmission lines in the U.S. cross the Appalachian Basin oil shale belt in Eastern Kentucky. Ashland Oil's Cattlettsburg refinery is located within a 50 mile radius of some of the best oil shale in Kentucky. New refineries would not have to be built to develop the resource. Thus the size and capital requirements for a commercial Eastern oil shale plant could be small. Capital investment is a major impediment to the development of new energy sources. The ability of Eastern shale to deliver a broad range of products such as high- and medium-Btu gas, specialty chemicals, sulfur and surplus power provides flexibility which the lowers economic risk.

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[c] **Low grade**: the energy equivalents of Eastern and Western oil shale are almost the same. A typical Western oil shale has approximately 10.7% organic carbon and has a heating value of 2140 Btu/lb. The average defined Devonian oil shale in Eastern Kentucky has 11.7% organic carbon and has a heating value of 2110 Btu/lb. **Thin Seams**: Western oil shale must be mined under ground, which limits recovery. Fifty percent recovery of a 100 thick foot strata in the West is equivalent to 100% recovery of a fifty foot strata in the East, which is the approximate thickness of oil shale in Fleming, Montgomery, Bath, Rowan and Powell Counties of Kentucky (Robl et. al, *Geochemistry and Chemistry of Oil Shale*, American Chemical Society, 1983). **High Stripping Ratio**: Kentucky oil shale outcrops around the Bluegrass where, of course, it has a stripping ratio of zero.

[d] Gaire, R.J., G. Mazzella and T.J. Hand, Eastern Oil Shale Symposium Proceedings, Institute for Mining and Minerals Res., University of Kentucky, Lexington, KY, p. 499, (1989). See also U.S.DOE, Fossil Energy Reports: DOE/MC/22134-2585 (1987); DOE/MC/22134-2539 (1987); DOE/MC/22134-2634 (1988); and, DOE/MC/22134-2698 (1989).

Social Considerations. Oil shale mining is congruent with the socio-economic base indigenous to the east. Major Eastern oil shale deposits are located adjacent to the Appalachian Coal Basin and the Eastern Interior Coal Basin. There were approximately 47,000 people involved in coal mining in 1980 in Kentucky and approximately 31,500 in 1988. Thus, there is a large mining community capable of developing Eastern oil shale, and sorely in need of work.

Environmental Considerations. The East has abundant rainfall and water resources. This makes reclamation of mined lands easier and more effective. Eastern oil shale can be surfaced mined, which allows for complete resource recovery and is less costly than underground mining. With this type of mining, the spent shale can be returned to the mine and the topographic character of the land preserved.

Perhaps most importantly, Eastern shales are silicates which produce far less CO_2 when heated to process temperatures than the carbonate shales of the Western U.S. There few other energy resources that would produce more CO_2 per Btu of product than Western U.S. oil shale. For example, the Occidental Modified In Situ (MIS) retort uses a combustion front and steam to retort the shale. This results in full or at least partial decomposition of the shale rock resulting in the emission of gaseous CO_2 (retort temperatures in excess of 600 °C, well above calcination temperature, were generated in the Occidental In Situ retort 7 and 8 tests[e]). A 50,000 ton-per day MIS retort would result in the emission of approximately 0.4 of a standard cubic mile per year from calcination alone.[f] This is CO_2 liberated indirectly as a by-product, not as the result of the actual conversion of energy. When the figures from combustion of the shale in the MIS retort are added, the potential for CO_2 generation doubles or triples.

I would also point out that originally one of the major environmental concerns relevant to the development of Western U.S. oil shale is the impact of the large quantities of low (50-75 Btu/SCF) CO_2-rich off-gas on regional air quality. This was before the development of the current state of concern of the effect of excessive CO_2 production on global air quality.

High CO_2 production is not just a function of MIS technology. Fischer Assay of Green River oil shale typically produce gases with CO_2 contents which range from 20 to 30% of the total gas volume compared to 1 to 2% for Eastern U.S. oil shales.[g]

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e. Hommert, P.J., 1983, Oil Shale Program, 26th Quarterly Report, Sandia National Laboratory, SAND82-2699, 40 p.

f. This assumes an oil shale of 18% CO_2 by weight, which is the average of 66 different western shales analyzed by Lawrence Livermore National Laboratory. (Singelton, et al., Assay Products from Green River Oil Shale, LLNL, UCRL-53273, 185p. (1982)).

g. Rubel, A.M., et al, 1982, Analysis of Products from Bench Scale Retorting of Kentucky Oil Shales, East. Oil shale Symp., p. 51.

Research Funding Recommendations.

Eastern oil shale is an immense resource with great potential. Research over the past ten years has greatly advanced our understanding of and lowered its development costs to the point where they are comparable to, or lower than, that for Western U.S. oil shale. In addition, the location of Eastern oil shale, in or near where it is needed, will result in lower infrastructure development and transportation costs. Low greenhouse gas emissions also makes the Eastern oil shale resource more attractive environmentally.

Research efforts must be continued to confirm the viability of new Eastern oil shale technologies and to bring them to a point where they can be taken to commercial scale. The development of oil shale in the U.S. is long term and is most logically approached by supporting stable research programs which help to maintain a core of expertise. This has also been the policy of the United States Congress for the past five years. For fiscal year 1991 we support a $8.5 million dollar program for Eastern oil shale research including;

- $4.35 million dollars to initiate the scale up of the PFH process at the Institute of Gas Technology.

- $1.15 million dollars for further cost improvements of the PFH process at the Institute of Gas Technology.

- $375,000 for continued development of the KENTORT II technology at the University of Kentucky, Center for Applied Research.

- $380,000 dollars for environmental studies of retorted Eastern oil shale at the at the University of Kentucky, Center for Applied Research.

In closing I would like to add that there are some who are lobbying for a large single oil shale project at the demonstration level in the Western U.S. This would essentially consume all the financial resource which has been historically available for oil shale research on a national level, for an investment in a single unproven technology. We do not believe that today's energy economics and technical understanding warrant such a project or the resultant abandonment of the regionally balanced program of oil shale research. We support the continued funding for both Eastern and Western U.S. oil shale research, which has been the policy of the United States Congress over the past eight years.

Mr. **Morrison.** Thank you, Doctor.

Dr. Muehlhaus I can see now why we put you in between these two witnesses, Doctor. [Laughter.]

STATEMENT OF DR. JOEL W. MUEHLHAUSER, ADMINISTRATOR, ENERGY CONVERSION R&D PROGRAMS, THE UNIVERSITY OF TENNESSEE SPACE INSTITUTE, KNOXVILLE, TN

Dr. **Muehlhauser.** Thank you, Mr. Chairman. My name is Joel Muehlhauser, I'm the Administrator of the Energy Conversion Programs at the University of Tennessee Space Institute, and I appreciate the opportunity to address the subcommittee on the subject of MHD.

MHD is the energy conversion technology which holds the potential for achieving the highest plant efficiency while exceeding all standards for environmental intrusion. The environmental benefits of the technology have been investigated extensively. Based on experimental verification, we have found that the SO_2, NO_x, and particulate emission levels are well below the existing NSPS standards.

A number of environmental advantages can also be realized from the potentially high efficiency in MHD. For example, on a per-unit-of-electrical-power-produced basis, less waste heat is discarded, less cooling water is required, proportionately less coal is transported, and less stack gas is produced, which means less CO_2.

The current MHD program being implemented in the United States is the result of a consensus established in public meetings held by DOE in 1984. The public meetings were followed by the formulation of a coal-fired MHD preliminary transition and program plan. Presently, this plan calls for completing a proof of concept program for coal-fired MHD electrical power plants in 1993.

The resulting program is focused on the least cost, shortest development time path to establish the comprehensive data base needed for a private sector decision regarding the commercialization of MHD technology. There are four essential elements in the proof of concept program: number one, prepare a conceptual design for an MHD retrofit plant; number two, develop technical and environmental data for the MHD integrated topping cycle system through long term proof of concept testing at the Component Development and Integration Facility in Butte, Montana; number three, develop technical and environmental data for the MHD integrated bottoming cycle subsystem through long term proof of concept testing at the Coal-Fired Flow Facility in Tullahoma, Tennessee; and, number four, design and construct a seed regeneration system capable of independent operation, using spent seed materials from the MHD process, at TRW's facilities in California.

As a result, four major concurrent acquisition activities were conducted in 1987. Hardware research and development activities needed to complete the proof of concept test program were put in place at the start of 1988. Briefly, the status of these four elements are as follows.

The number one element, the conceptual design study, was completed this past year. Two conceptual design studies were completed on existing coal-fired plants. This information is being used to verify the data that is being collected at the integrated topping cycle and bottoming cycle facilities.

The integrated topping cycle testing is ongoing and preparing to develop data that will be used in designing the 1,000-hour proof of concept testing at that facility. The integrated bottoming cycle testing has reached the 1,500-hour point, going toward 4,000 total hours of proof of concept testing, and that data is being used.

The fourth item, the seed regeneration contract, that contract was just awarded last year to TRW, and it is on schedule. So, basically, all four elements are on schedule and meeting the date of 1993.

In conclusion, we would like to recommend that the funding level for the MHD program be restored to the $45.5 million level which we recommend in order to keep this technology on schedule and also to keep this country's leadership role in this field.

I thank you, and I'd be willing to answer any questions that you may have.

[The prepared statement of Dr. Muehlhauser follows:]

Statement of Joel W. Muehlhauser
Administrator
Energy Conversion R&D Programs
The University of Tennessee Space Institute
Tullahoma, Tennessee 37388

to

The Subcommittee on Energy Research and Development
Committee on Science, Space, and Technology
U. S. House of Representatives
Washington, D. C. 20515
June 20, 1990

Madam Chairwoman and Members of the Subcommittee, I am Joel Muehlhauser, Administrator of the Energy Conversion R&D Programs at The University of Tennessee Space Institute. I appreciate this opportunity to testify regarding the magnetohydrodynamics (MHD) research and development program. Significant progress is being made and I sincerely appreciate the support of this Subcommittee in the past and solicit your continued support in the future for this vital program.

MHD is the energy conversion technology which holds the potential for achieving the highest plant efficiencies while exceeding all standards for environmental intrusion. Coal-fired MHD plants have experimentally verified levels of sulfur dioxide (SO_2), oxides of nitrogen (NO_x), and particulate emissions well below the New Source Performance Standards of 1979 without using expensive exhaust gas cleanup systems required on conventional power plants. Data obtained at the U. S. Department of Energy's Coal Fired Flow Facility, located on the campus of the University of Tennessee Space Institute near Tullahoma, Tennessee, have verified the environmental performance of coal-fired MHD technology. Recent tests resulted in over 98% of the sulfur dioxide removed from the burning of high sulfur Eastern coal while at the same time reducing NO_x emissions to one-sixth the level set by the New Source Performance Standards.

NATIONAL MHD PROGRAM

The national MHD development program is currently funded by the U. S. Department of Energy (DOE), through its

Pittsburgh Energy Technology Center. The program objectives are to establish, through proof-of-concept testing, an engineering data base which will allow the private sector to evaluate the risks and benefits of the technology before proceeding with commercial demonstration of MHD. The Proof-of-Concept (POC) program is aimed at performance and lifetime of major components and subsystems, and contains four major elements:

1. MHD Retrofit Conceptual Design program, to prepare conceptual designs of two possible MHD retrofit plants;

2. The Integrated Topping Cycle program, to demonstrate scalability, performance and lifetime of the MHD topping cycle through long duration (1000 hours) testing;

3. The Integrated Bottoming Cycle program, to develop technical and environmental data for the bottoming cycle through long duration (4000 hours) testing;

4. The Seed Regeneration program, to design and construct a system to regenerate a useable seed compound from the spent potassium, sulfur and fly-ash removed from the MHD exhaust gas.

These programs were initiated in 1987 - 1988, and follow a lengthy period of component development. The major test programs are being conducted at two DOE test facilities, the integrated bottoming cycle activities at the 28 megawatt thermal (MW$_t$) Coal Fired Flow Facility (CFFF), near Tullahoma, Tennessee, and the integrated topping cycle at the 50 MW$_t$ Component Development and Integration Facility (CDIF), in Butte, Montana. The CDIF has a complete coal fired MHD power train, a 3 tesla iron core magnet, and an inverter which interfaces with the local utility grid. The CFFF has a complete heat recovery/seed recovery system (HRSR) fired by a coal fired flow train, but does not operate with a magnet.

PROGRAM STATUS

MHD Retrofit Conceptual Design - Conceptual designs of two repowered existing coal fired plants have been performed. These designs are useful in evaluating the practicality of the proposed repowering, in identifying interfaces between the MHD units and the existing plants, and in providing cost and schedule information. They also provide a framework within which to identify important issues and technology gaps to be addressed in the overall POC program. The two existing plants studied were the Montana Power Company's Corette plant in Billings, Montana, and Gulf Power's Scholz plant in

Sneads, Florida. The conceptual designs for the two plants were performed by teams led by the MHD Development Corporation, Butte, Montana, and the Westinghouse Electric Corporation, Pittsburgh, Pennsylvania, respectively.

Integrated Topping Cycle - The objective of the Integrated Topping Cycle program is to build and test, for a total of 1000 hours, an integrated coal fired MHD flow train consisting of a combustor, nozzle, channel, associated power conditioning equipment, and diffuser. The flow train and the operating conditions are intended to be prototypical of hardware for commercial plants, so that design and operating data can be used to project component performance, lifetime and reliability in commercial plants. The flow train will operate at 50 MW_t. The integrated topping cycle program follows an earlier program of component testing at the CDIF, and will conclude in 1993.

The program is being conducted by a team consisting of TRW, Inc., which is responsible for the coal fired combustor, as well as for integration of the overall effort; Avco Research Laboratory, Inc., which is responsible for the nozzle, the channel, the diffuser, and the power conditioning equipment; and the Westinghouse Electric Corporation, which will supply current consolidation equipment for the power take-off regions of the channel.

In order to support the design and fabrication of the prototypical flow train to be tested for the 1000 hours, extensive component testing at the 50 MW_t level is in progress at the CDIF; to date, over 100 hours of topping cycle component testing has been conducted, and 1.5 MW_e of electrical power has been generated with coal firing. In addition, testing of electrodes and sidewalls and of coal fired channels of 20 MW_t size has been accomplished at Avco.

Integrated Bottoming Cycle - The bottoming cycle program is being conducted with a heat recovery and seed recovery system, located at the Coal Fired Flow Facility in Tullahoma, Tennessee. The system includes a radiant furnace, secondary combustor, air heaters, superheater modules, cyclone scrubbers, a baghouse and an electrostatic precipitator. It is fired by a coal fired flow train rated at 28 MW_t. Long term testing is conducted, with the goal of obtaining 2000 hours of operation on each of two types of coal. The two coals of interest are Montana Rosebud, considered to be a representative low sulfur Western coal, and Illinois No. 6, a representative high sulfur Eastern coal. The goal of the integrated bottoming cycle program is to obtain an engineering data base for the HRSR components, so that operational characteristics, reliability, maintainability and materials performance applicable to commercial systems can be established. The program is being conducted by the University of Tennessee Space Institute, with assistance from Babcock & Wilcox Corporation, Argonne National Laboratory, and Mississippi State University.

With the goal in mind of providing data necessary for scale-up to commercial systems, the bottoming cycle components use existing boiler technology and materials wherever possible. Appropriate gas-side conditions are provided by a coal fired flow train which simulates as closely as possible the composition, temperature, and residence time, among other conditions, in a commercial MHD/steam plant. Specific aspects of system operation investigated include slagging, fouling, erosion and corrosion of heat transfer surfaces; identification, control and measurements of gaseous and particulate pollutants; waste management; seed recovery; heat transfer; and system integration and scaling characteristics.

To date the CFFF has operated over 1700 hours on coal with a total of 1500 hours on the POC program. The most recent test was a 215 hour test successfully completed last week.

Seed Regeneration - The objectives of the current program are to provide experimental verification of the feasibility of one of the seed regeneration processes which has been selected for the first commercial use. Specifically, the program goals are to test a specific process at bench scale, to design a POC test plant, and to prepare a conceptual design of a seed regeneration unit for a commercial MHD plant. The specific process under evaluation is the Econoseed process, which is based on the conversion of the recovered potassium sulfate seed to potassium formate, by means of reaction with calcium formate. The sulfur is removed as calcium sulfate, and the potassium formate is recycled. The work is being performed by TRW, Inc.

PROGRAM NEEDS

The national program continues toward completion of the Proof-of-Concept program by 1993. The program will culminate in a 1000 hour duration test of an integrated MHD power train at the DOE Component Development and Integration Facility in Butte, Montana, and over 4000 hours of duration testing of an integrated bottoming cycle at the DOE Coal Fired Flow Facility in Tullahoma, Tennessee.

Statement of Joel W. Muehlhauser
June 20, 1990

The following budget figures represent the needed funds (as recommended by the MHD Industrial Forum) to keep the program on schedule:

FY 90	FY 91	FY 92	FY 93	TOTAL
$40.4M	$45.5M	$39.5M	$27.3M	$152.7M

The major tasks which the funding will provide for FY 91 are:

Integrated Topping Cycle: Long lead hardware procurements, followed by fabrication and assembly of all subsystems, comprise the major activity for the 50 MW_t prototypical power train. The CDIF will initiate procurement of and installation of the oxygen system; continue the Data Acquisition system and upgrade of the nitrogen system. This funding and schedule is needed in order to meet the DOE-mandated hardware delivery schedule of March 1991 which is critical to meet the fiscal 1993 completion requirement. Without this level of funding for FY 1991, the ability to meet these program requirements, critical to the CDIF 1000 hour test, will be in significant jeopardy.

Integrated Bottoming Cycle:

1. Complete 2000 hours of Illinois No. 6 coal with 240 hours during the first quarter of FY 91.
2. Perform 400 hours of special tests on Illinois No. 6 coal and start 2000 hours of POC tests on Montana Rosebud coal.
3. Complete procurement, installation and checkout of Western coal conversion of the CFFF.

Seed Regeneration: Continue development of this critical system.

Support: The remaining funds are for DOE administration and ongoing support work. This support includes funding for superconducting magnet work at MIT and the diagnostic instrumentation support which Mississippi State University provides for both DOE test facilities.

Mr. **Morrison**. Thank you, Doctor.

I presume, in order to be fair to Dr. Zahradnik, that maybe I better run vote right now, so the Subcommittee will stand in recess for seven minutes. We'll make it fast. Thank you.

[Recess.]

Mr. **Morrison**. The Subcommittee will resume its hearing.

We have Mr. Raymond Zahradnik at this time.

STATEMENT OF RAYMOND ZAHRADNIK, PRESIDENT, OCCIDENTAL OIL SHALE, INC., STEAMBOAT SPRINGS, CO

Mr. **Zahradnik**. Thank you very much, Mr. Chairman. I am Ray Zahradnik, President of Occidental Oil Shale, and I'm pleased to testify this morning on the implications of the fiscal year 1991 budget request of the DOE for fossil energy research and development, especially as it relates to oil shale, and, as the others, I would have my written testimony for your record, and I'll make just a few summarizing remarks.

My company, Occidental Oil Shale, has been involved actively in the development of oil shale for nearly 20 years. We have developed to the point of commercial readiness a versatile technology that is uniquely suited to the oil shale deposits of the western United States. This process is known as modified-in-situ processing, because a large portion of the shale is left in place and retorted in the ground.

At our test facility in Colorado, over 300,000 barrels of oil have been produced from experimental MIS retorts. We have spent over $300 million of our own money on the development of MIS, as well as on resource acquisition, environmental monitoring, engineering studies, and socioeconomic mitigation measures.

Private industry, as a whole, has spent over $3 billion on oil shale projects in the west in the last 15 years. The Federal Government has spent less than 10 percent of this amount. However, the Federal Government has played a significant role in catalyzing private interest. In the early 1970s, the Department of Interior sparked interest in oil shale by initiating the Oil Shale Prototype Leasing Program, which offered for lease six Federal tracts in Utah, Wyoming, and Colorado.

In the late 1970s, the Department of Energy actively promoted oil shale development. My own company received nearly $40 million in cost-shared grants for the development of the MIS technology. In the early 1980s, the Synthetic Fuels Corporation promised large scale support to potential commercial oil shale projects. Since that time, however, there has been a void in Government leadership, which, in turn, has contributed to a decline in private interest.

The DOE budget request for fiscal year 1991 of $662,000 continues this policy of neglect. This request is totally disproportionate to the extent of the oil shale resource, as well as the ability of shale oil to contribute significantly to the real energy problems facing the United States in the decades ahead.

As you know, the United States has the largest oil shale deposits in the world, estimated to contain over 1,000 billion barrels of recoverable oil. This exceeds the current known supply of conventional oil in the world. The majority of the oil shale deposits are found in thick, deep seams of the western United States, which are accessible primarily by underground mines which are red and gassy.

These deposits can be recovered most economically and efficiently when modified-in-situ processing is combined with above-ground retorting. We estimate that such combined processing can produce upgraded shale oil in relatively small commercial plants for less than $30 per barrel. Private development of oil shale to realize these economics is unlikely to occur in any timely way, because most investors will base their decision on pessimistic estimates of cost.

I want to quote from a background paper prepared by the Office of Technology Assessment in 1985. I quote, "The only way to obtain accurate costs for synfuel production and confidence and thereby reduce investment risk in the technology is to construct and operate one or more pioneer plants. Until such facilities are built and operating, most investors will base their decisions on pessimistic estimates of the cost of synfuels. As a result, extensive investment in synfuel production could be delayed until oil prices rise to well above the cost of synfuels."

Of course, this statement holds true for oil shale today. If there is no visible Government program in oil shale, industrial involvement will be kept at very low maintenance levels. Yet the ability of oil shale to respond to the future energy needs of the country is not just limited to its great size. In fact, today, Unocal's oil shale plant at Parachute Creek in Colorado has produced over three million barrels of shale oil which have been processed in refineries in Colorado, Utah, and Illinois.

In all cases, the shale oil produced exhibited superior properties. One hundred percent of it is turned into transportation fuels. It makes it the best alternative in the world as far as the production of transportation fuels are concerned. Moreover, the characteristics of shale oil make it a preferred feed stock for the production of reformulated diesel fuels.

However, as I noted, even though the deposits of oil shale are enormous, and even though shale oil is a superior feed stock for refineries, its commercial production is at least a decade away. This is how long it will take to develop and demonstrate the additional technologies to achieve satisfactory commercial economics.

It's important to recognize the length of time needed to establish a commercial oil shale industry. Because of this lengthy period, the Federal Government must maintain a constancy of policy and a consistency of funding. Otherwise, the efforts to establish an oil shale industry will falter and die.

Therefore, I conclude that a visible, significant and continuing DOE budget for oil shale research and development is needed if the oil shale industry is to develop in a timely way. Moreover, I foresee that it will be necessary for the DOE to work with industry in a cooperative and innovative manner.

A similar need was recognized by the National Research Council in the published study that's been referenced all morning. This study concluded that the current shale oil program was too small, and I concur. The recommendation was, among other things, to construct a field facility, both to demonstrate technology as well as to confirm the potential of producing shale oil at competitive costs, and I also concur.

I would like to note that this study addressed the key issue relating to our energy future, namely, transportation fuels. The United States is able to meet all its future needs for heating, electricity and industrial processing for its abundant natural resources, as well as by effective programs in renewable energy and conservation.

However, in the transportation sector, we are today as dependent upon the imported oil as we have ever been, and that situation will only grow worse in the years to come if we continue our present path. We know that because of the unique graphic, demographic and cultural situation in the United States, we simply use more oil for transportation than any other country. I believe it's appropriate for futurists and energy policy makers to question the lifestyle resulting from these conditions and examine oil conserving options.

I also believe it is appropriate for policy makers to examine realistic economical ways to protect that lifestyle. Oil shale can contribute sizable quantities of competitive domestic transportation fuels to the Nation in a period of 10 years from now if we start today.

Now, from the perspective of this Committee, there must be several ways to promote and encourage cooperative R&D efforts in oil shale, and I would urge the study of all of these options and decisive action taken to start those that look favorable. I would like to inform you of one specific plan for carrying out a cooperative Government-industry program that involves State and local governments as well.

At the urging of the Associated Governments of Northwest Colorado in 1986, the Oil Shale Action Committee was formed as a coalition of interested parties in the west—industrial companies, State and local government officials from the States of Utah, Wyoming, and Colorado.

This coalition advised Congress to appropriate funds beginning in fiscal year 1990 for the design, construction and operation of a proof of concept facility in the west. Occidental has joined this coalition and has offered the use of its C-b tract as a site for the facility. The C-b tract, by the way, is one of the original six leasehold tracts included in the Department of Interior's Prototype Leasing Program.

We estimate that a facility on our site using our technology and others would take three years to design and build and another four to seven years of operation to complete the testing. The net project cost over this seven- to 10-year period is estimated to be about $200 million. Occidental is prepared to fund half of this cost if Federal, State and local governments provide the other half.

At the completion of the project, we would expand the facility to commercial size with private financing. Due to the long term nature of the project, a multi-year expression of support is needed from the Federal Government. An initial appropriation of $8 million to $10 million for fiscal year 1991 will, when matched with Occidental's funds, as well as State and local funds, complete the final design and initiate field construction in mining in 1991.

The Federal Government's share of the project would average about the same per year if costs are levelized for the term of the project. The actual DOE budget for oil shale has been around $10 million per year for the last few years. Consequently, a modest increase to the rate of $15 million to $20 million per year would be required to bring the oil shale budget more in line with its strategic importance to the Nation.

The proposed project has tremendous advantages to the Federal Government with regard to time and cost. An extensive infrastructure exists at Tract C-b that provides the project with at least a five-year lead time over any other conceivable effort, and it benefits over $350 million having been spent on the tract which would now be sunk costs.

I believe this represents the best offer that the Federal Government could possibly get for oil shale development. In addition, the project provides a careful, focused program for oil shale development for the rest of the decade. At the present time, over 20 independent contractors, universities, and institutes are involved with Occidental in the project. I urge that the fiscal year 1991 DOE oil shale budget include funds to begin this work.

I further urge that this Committee encourage or even authorize the DOE to plan to include funds in its future budget requests to continue the project and thereby lay the foundation for a privately-funded domestic shale oil industry that will produce sizable quantities of transportation fuels to meet our 21st century needs.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Zahradnik follows:]

STATEMENT
ON
OIL SHALE DEVELOPMENT
IN THE
UNITED STATES

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PRESENTED TO

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE,
SPACE, AND TECHNOLOGY

JUNE 20, 1990

INTRODUCTION

Good Morning, Madame Chairman. I am Ray Zahradnik, President of Occidental Oil Shale, Inc. I am pleased to testify this morning on the implications of the FY 1991 budget request of the Department of Energy (DOE) for fossil research and development, especially as it relates to oil shale research.

Occidental Oil Shale, Inc. (OOSI) has been active in the development of oil shale for nearly 20 years. We have developed a versatile technology that is uniquely suited to the oil shale deposits of the Western United States. This process is known as Modified-In-Situ (MIS) processing because a large portion of the shale is left in place and retorted in the ground. We have spent over $300 million of our own money on the development of MIS as well as on resource acquisition, environmental monitoring, engineering studies and socio/economic mitigation measures. Private industry as a whole has spent over $3 billion on oil shale projects in the West. The Federal Government has spent less than 10% of this private sector amount.

However, the Federal Government has played a significant role in catalyzing private interest. In the early 1970's the Department of Interior sparked interest in oil shale by initiating the Oil Shale Prototype Leasing Program which offered for lease 6 federal tracts in Utah, Wyoming and Colorado. In the late 70's, the Department of Energy actively promoted oil shale development. My own company received nearly $40 million in cost-shared research grants for the development of MIS technology. In the early 80's, the Synfuels Corporation promised large scale support to potential commercial oil shale projects.

There has been a void in government leadership since the abolishment of the SFC, which, in turn, has contributed to a decline in private interest. The DOE budget request for FY 1991 of $662,000 would continue this policy of neglect. Moreover, the request is totally disproportionate to the extent of the oil shale resource as well as the ability of shale oil to contribute significantly to the real energy problem facing the United Sates in the decades ahead.

RATIONALE FOR AN OIL SHALE PROGRAM

The United States has the largest oil shale deposits in the world, estimated to contain over 1000 billion barrels of recoverable oil. The majority of this oil is found in the thick, deep seams of the West which are accessible primarily by underground mines which are wet and gassy. These deposits can be recovered most economically and efficiently when Modified-In-Situ (MIS) processing is combined with above Ground Retorting (AGR). We estimate that such combined processing can produce upgraded shale oil in relatively small commercial plants for less than $30/bbl. Unocal is developing AGR technology on a commercial scale at their

Parachute Creek facility. Comparable development of MIS technology is needed to realize the $30/bbl projected commercial economics.

Confirmation of the viability of MIS technology and the validity of the combined process cost estimates would greatly expand U.S. oil reserves. Since most of the Western oil shale belongs to the Federal Government, production of these reserves at even modest royalties would provide many billions of dollars to the U.S. Treasury. Further, private development of oil shale is unlikely to occur in any timely way because most investors will base their decision on pessimistic estimates of the cost. I quote from a background brief prepared by the Office of Technology Assessment in 1985.

> "The only way to obtain accurate costs for synfuel production and confidence and thereby reduce investment risk in the technology is to construct and operate one or more pioneer plants. . . . Until such facilities are built and operating, most investors will base their decisions on pessimistic estimates of the cost of synfuels. As a result, extensive investment in synfuel production could be delayed until oil prices rise to well above the cost of synfuels."

This statement holds true today for the oil shale industry.

Many legislators and oil economists have stated that oil shale is too expensive and does not warrant government attention at this time. But our estimates show that small commercial plants using combined MIS and AGR processing will produce a premium quality syncrude for $30/bbl. Larger plants will do even better.

This cost is higher than today's world oil price, so commercial viability depends upon the real growth of oil prices in the years ahead. Most reasonable people agree that oil prices will rise in real terms. In that case, I think it is more valuable to find out what the costs of producing shale oil really are rather than dismissing shale with trite and self-serving arguments that it's too expensive.

INDUSTRY EFFORT.

The ability of oil shale to respond to the future energy needs of the country is not just limited to the great size of its resource base. Shale oil is a premium product which has been utilized by existing refineries in the United States. Unocal's oil shale plant at Parachute Creek has produced over 3 million barrels of shale oil which have been processed in refineries in Colorado, Illinois and Utah. In all cases the shale oil exhibited superior properties -- 100% of it is turned into transportation fuels. Moreover, the characteristics of shale oil make it a preferred feedstock for the production of reformulated diesel fuel.

However, it must be understood very clearly that even though shale oil is a superior feedstock for refineries, its commercial production is at least a decade away. This is how long it will take to develop and demonstrate the additional technologies needed to achieve commercial economics. It is important for this committee to realize the length of time needed to establish a commercial oil shale industry. Because of this lengthy period, the Federal Government must maintain a constancy of policy and a consistency of funding. Otherwise, the efforts to establish an oil shale industry will falter and die.

Throughout the 70's and early 80's the incentives provided by the Federal Government that I mentioned earlier, drove private industry's efforts both in R&D and in commercialization. Several projects were engineered and designed, only to be abandoned as Federal incentives were withdrawn. This process is at best inefficient and at worse, it totally undermines the overall objective of establishing an oil shale industry.

COOPERATIVE EFFORTS

Therefore, I conclude that a visible, significant and continuing DOE budget for oil shale research and development is needed if the oil shale industry is to develop in a timely way. Moreover, I perceive that it will be necessary for the DOE to work with industry in a cooperative and innovative way.

A similar need was recognized by the National Research Council in their recently published study, "Fuels to Drive our Future." This study concluded that the current shale oil program was too small. The recommendation was to construct a field facility both to demonstrate technology as well as to confirm the potential of producing shale oil at competitive costs. I would like to note that this study addressed the key issue relating to our energy future, namely transportation fuels. The United States is able to meet all of its future needs for heating, electricity production and industrial processing from its abundant natural resources as well as by effective programs in renewable energy and conservation. However, in the transportation sector we are today as dependent upon imported oil as we have ever been, and that situation will only grow worse in the years to come if we continue on our present path.

Because of the unique geographic, demographic and cultural situation in the United States, we simply use more oil for transportation than any other country. I believe it is appropriate for futurists and policy makers to question that lifestyle and examine oil conserving options. I also believe it is appropriate for policy makers to examine realistic, economical ways to protect that lifestyle. As I noted, oil shale can contribute competitive domestic transportation fuels to the Nation in a period of ten years. But we must start today.

A SPECIFIC PROPOSAL

From the perspective of this committee there are several ways to promote and encourage cooperative R&D efforts in oil shale. I would encourage study of these options and decisive action taken to start those that look favorable. I would like to inform you of one specific plan for carrying out a cooperative government/industry program that involves state and local governments as well.

At the urging of the Associated Governments of Northwest Colorado in 1986, the Oil Shale Action Committee was formed as a coalition of interested industrial companies and state and local government officials in Utah, Wyoming and Colorado. This coalition advised Congress to appropriate funds beginning in FY 90 for the design, construction and operation of a proof-of-concept facility in the West. OOSI has joined this coalition and has offered the use of its C-b tract as a site for the facility. (The C-b site, by the way, was one of the six tracts included in DOI's Prototype Lease Program).

The Oil Shale Committee of the Rocky Mountain Oil and Gas Association (RMOGA) has endorsed the project. The membership of this Committee includes most of the major oil companies that have oil shale holdings.

The Governor of Colorado, Roy Romer, is supportive of the project and has expressed his support by providing $400,000 to a currently ongoing study to complete the design of the facility. Senators and Congressmen from Colorado and nearby states have endorsed the project.

Although the project is proposed to be located in Colorado, it is regional in nature. We expect to purchase a considerable amount of equipment and other services from vendors and institutions in Utah, Wyoming and elsewhere in the West, and we expect our results to be applicable through the Western Oil Shale Region. Moreover, the Project is open to third parties interested in testing above ground retorting and other technologies at Tract C-b.

A proof-of-concept facility should ease the familiar boom/bust cycle associated with mineral recovery in the West. By providing for a multi-year trial period before commercialization, the project will allow local communities and counties time to develop appropriate infrastructures to deal with the emerging industry. Technical people can prosper and grow in such a program and provide an experienced cadre of personnel to operate commercial plants.

Finally, the project would contribute insight into environmental issues which, in addition to the large data base already established by Unocal, should enable oil shale development to proceed in strict compliance to environmental regulations and in sympathy with environmental concerns.

In hearings before the House Subcommittee on Interior and Related Agencies - Committee on Appropriations, I described the proposed project in some detail.

We estimate that the facility on our site using our MIS technology would take 3 years to design and build, and another 4-7 years of operation to complete the testing. The net project cost over a 7-10 year period is estimated to be about $200 million. OOSI is prepared to fund half of the cost, if federal, state and local governments provide the other half.

Due to the long-term nature of the project, a multi-year expression of support is needed from the Federal Government. An initial appropriation of $8-$10 million for FY 91 will, when matched with OOSI and state and local funds, complete the final design and initiate field construction and mining in 1991. The Federal Government's share of the project would average about the same per year if costs are levelized for the term of the project. The actual DOE budget for oil shale has been around $10 million per year for the last few years. Consequently, a modest increase to the rate of $15-$20 million would be required to bring the oil shale budget more in line with its strategic importance to the nation.

This project provides a careful, focused program for oil shale development for the rest of the decade. I urge that the FY 1991 DOE oil shale budget include funds to begin this work. I further urge that the DOE plan to include funds in its future budget request to continue the Project and thereby lay the foundation for a privately funded domestic shale oil industry that would produce sizable quantities of transportation fuels to meet our 21st Century needs.

Mr. MORRISON. My thanks to all three of you. Obviously, since a number of the members of the subcommittee are not here, there will be written questions that we would like to be able to submit to you. It's been interesting to listen to the exchanges on oil shale. I think the common threads, at least in your comments to us, is that it's a vast resource, that it needs research dollars to answer one of America's vexing problems, and that is for transportation fuel, and it probably is a decade away, even if we made the major investments right now.

I do detect some differences between east and west, and both interests are represented here on this subcommittee, and it's probably one of the reasons you've seen the funding levels in the past, when the Department has not smiled on this program.

I guess one of the differences that's of interest to me is the private investment seems to be heavily in the west, and the east, however, perhaps has generated more State investment in the programs.

Mr. Zahradnik, your proposal is rather interesting. You say that's essentially all ready to go, it just requires the public investment. Has the Department of Energy reacted to that in any way?

Mr. ZAHRADNIK. We've had many discussions with the Department of Energy. I've had occasion to discuss it with Mr. Gentile, who was here earlier, and, actually, I presented testimony to Henson Moore and had a discussion with Admiral Watkins about it. I believe they find the proposal to be very attractive to them but find that it needs to be put into the overall Government budgeting system where other priorities have to be weighed against it, and we'll just have to see how it turns out.

We have had—and let me emphasize, and I did this in my written statement—tremendous recent support from the State of Colorado. We're carrying out some planning studies right now in which the State of Colorado is providing $400,000, and they have promised to provide at least $1 million in actual dollars, as well as other ways of helping us, each year for the duration of the project.

I think that in the west, in the past, where there has been a lot of money spent and a lot of intense interest that's generated, a boom-bust cycle, this has not been very appealing to the State and local governments, but our approach, which is more steady and more deliberate and starts with a smaller facility in order to test out not merely the technology but the environmental conditions of socioeconomic impacts on the cost, has more appeal to them, and, as a result, we have found a lot of encouragement, not just financially but otherwise, from all of the elected representatives in the area.

Mr. MORRISON. Thank you.

Dr. Derbyshire, I'd like to ask you about two things. One is the rather promising technology of KENTORT II. Is industry participating in phase two of that development?

Mr. DERBYSHIRE. At the moment, no. In fact, the scale-up that we're moving to now, which is this agreed three-year contract with the Department of Energy, would then take this project to a scale where we can develop materials in meaningful quantities for economic development and bring it to that bridge point, if you like, where industry would then be able to take this data and to build that into their own plans to see that there's a viable operation at that state. So we're in that stage of proofing, if you like.

Mr. MORRISON. I would presume from what I sense are the differences geographically between your two areas that are represented here that the in-situ concept does not apply in the east.

Mr. DERBYSHIRE. No, it doesn't.

Mr. MORRISON. So we really have two different technologies that need to be demonstrated in this program.

Mr. DERBYSHIRE. That's right. There are two resources of quite different characteristics which even require different means to develop them, and we're looking at two, if you like, parallel sets of activity involving two very large components of the natural resource.

Mr. MORRISON. Also, the other question I wanted to ask you, Dr. Derbyshire, is, this National Research Council, you sort of took it on the chin there, and you've indicated that at least parts of their conclusions are not accurate.

Mr. DERBYSHIRE. Yes.

Mr. MORRISON. Have you had a chance to refute some of that data with them and with the Department of Energy?

Mr. DERBYSHIRE. No, I haven't. The reason for focusing on that very much was that the recommendations which had come from that was to eradicate any activity in eastern oil shale, and we feel very strongly that there are substantial reasons for countering that and that it wasn't given a good hearing in that committee.

Mr. MORRISON. Well, I'm sure that some of the members of this subcommittee will agree with you.

Dr. Muehlhauser, It has to be a little discouraging to be zeroed out continually.

Dr. MUEHLHAUSER. Well, it's nothing new.

Mr. MORRISON. You're getting used to it now?

Dr. MUEHLHAUSER. Right.

Mr. MORRISON. Of course, I guess we're getting used to putting money back in. I wondered if you could tell me whether the proof of concept will be completed in time to catch round five of the clean coal technology?

Dr. MUEHLHAUSER. Yes, we believe it is. What is being planned, there is a proposal team being organized to put in for clean coal five. Of course, now with the delay in those, we're not sure. Maybe it could be moved up, but we're positive we can put one in.

Mr. MORRISON. There's a little question, of course, about round five; however, we think that's going to be worked out before the clean air bill is finally all the way through. Also, could you catch me up and the record on the status of foreign competition on MHD?

Dr. MUEHLHAUSER. Yes, I have personal knowledge of two countries, Italy and China. We are working with both of them on a contractual basis to help them develop MHD technology, but they are behind us at the present time, I think, as well as the Soviet Union is slightly behind us. They are also aggressively pursuing the technology.

So we have several countries that are aggressively pursuing this, and if we drop it, they will take over and take over the leadership of this program. At the present time, I feel we have the leadership role, but it can only stay that way if we maintain and continue the funding of the program.

Mr. **Morrison**. You appear to have friends at the Congressional level.

Well, gentlemen, I thank you very much, and, again, we appreciate the testimony of all the witnesses today, and, with that, we will conclude this hearing on the fossil research and development budgets.

[Whereupon, at 12:41 p.m., the Subcommittee was adjourned, to reconvene at the call of the chair.]

APPENDIX

Fuel Cell Association
Suite 403
1627 K Street, NW
Washington, DC 20006

July 10, 1990

The Honorable Marilyn Lloyd
Chairman, Subcommittee on Energy R&D
House Committee on Science,
Space and Technology
B-374 Rayburn House Office Building
Washington, D.C. 20515

Dear Madam Chairman:

Enclosed is the Fuel Cell Association's statement regarding the Department of Energy's proposed fiscal year 1991 fuel cell budget. The Association very much regrets that it was unable to present its oral testimony to the Energy R&D Subcommittee at the hearing scheduled for late June. Extremely unusual last-minute circumstances occurred to prevent both our planned representative and his alternate from appearing. We would, of course, appreciate the opportunity of presenting our oral testimony at future sessions of the Subcommittee.

Last March, members of the Energy R&D Subcommittee expressed interest in offering amendments to proposed clean air legislation that would help make fuel cells a viable commercial power generation option. This interest arose because fuel cell power plants produce practically no air or water pollution and they minimize the amount of carbon dioxide released to the atmosphere. Allow me to reiterate the Association's offer made at that time to assist the Subcommittee in the preparation of these amendments. Many of our members would be pleased to contribute their time and expertise to this worthwhile cause. Please contact me at Area Code 517 636-0411 or Martin Gutstein at 681-3532 if FCA can still be of assistance.

Sincerely,

Jeffery Gunsher
President

cc: M. Gutstein

Fuel Cell Association
Suite 403
1627 K Street, NW
Washington, DC 20006

STATEMENT OF

THE FUEL CELL ASSOCIATION

For the

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

-June 20, 1990--

STATEMENT OF
THE FUEL CELL ASSOCIATION
For the
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

-June 20, 1990--

Introduction

Concerns about the U.S. energy situation continue to be expressed. The causes for these concerns include: the continuing decline of domestic production of petroleum; the need for new, clean transportation fuels; looming electric power shortages; and, finally, the potential for adverse and, perhaps, irreversible environmental changes (i.e., global warming, acid rain) arising, to an important extent, from the nation's energy-production facilities and its transportation fleet.

Because fuel cells offer high conversion efficiencies and extremely low emissions, they have the potential, if widely deployed, to help resolve many of the above concerns. **The Fuel Cell Association believes, therefore, that the Nation must place a higher priority on support for the development and use of fuel cell technologies.**

Fuel Cells and National Policies

During the past year or so, a number of legislative proposals have been offered in Congress to alleviate the country's energy and environmental problems. Likewise, President Bush promised to become the "Environmental President," a role we fully support. This past year has also seen the Department of Energy undertake a major activity aimed at developing the Administration's National Energy

Strategy. We commend the President, Congress, the Administration, and the Department of Energy for their efforts to formulate and implement needed policies in the interrelated fields of energy and the environment.

While no one solution can answer all the energy and environmental challenges facing the U.S., fuel cells are a significant part of the response. **Fuel cells generate electric power at one of the highest efficiencies known to Man while producing the least pollutants of all fuel-consuming electric power generating systems.** Because of these characteristics and in view of the problems faced by this country, FCA expects fuel cells to play a significant role in the plans of this Administration and the Department's National Energy Strategy. Likewise, we look to Congress to continue to maintain and, indeed, to strengthen the federal support this technology has received in the past nine years.

Fuel Cells Have a Major Role in Energy Conservation and Protecting the Environment

Unlike combustion-driven engines (diesels and turbines), fuel cells convert hydrogen-rich fuel gases directly into electricity by means of an electrochemical reaction. Their unique conversion efficiencies, from 40 to 65 percent, are due to the absence of friction-limiting moving parts and the very high reactivity of the fuels and oxidants, which results in complete chemical reactions. Since there is no combustion occurring in fuel cells, there are no acid rain-promoters.

Because of these efficiencies, fuel cells use less fuel per kilowatt-hour of power produced than any other fuel-consuming generating system: **Fuel cells are therefore the preeminent fuel-conserving power plant.** Moreover, a fuel cell plant can operate as a cogenerator. In this mode of operation, fuel cells beneficially use about 85 percent of the energy of a fuel.

While still a controversial subject, CO_2 is considered a major cause of the global warming/greenhouse effect. Depending on the fuel used, carbon dioxide can be a fuel cell waste product, however, the amount produced is a fraction of that discharged by conventional fuel-burning power systems at an equivalent capacity; hence, a significant reduction in atmospheric CO_2 contribution is realized. **Unlike combustion-driven engines, fuel cell power is friendly to the environment.**

Continuation of the Federal Government's Support of Fuel Cell Development Is an Excellent National Investment

The eventual markets for fuel cells are potentially vast; they include gas and electric utilities, independent electric power producers, industrial and commercial buyers of electric generating systems, and transportation vehicle manufacturers: **These markets represent major portions of the economy of this country.** To enter these markets, U.S. suppliers and users of fuel cell systems need federal help in two key areas, i.e., a better balanced federal fuel cell R&D program and a federal role in scale-up demonstrations.

BALANCED FUEL CELL R&D PROGRAM: FCA notes that substantial progress in fuel cell development is being made by overseas companies. FCA welcomes this competition as a way of speeding the introduction of fuel cells into the market place. However, overseas companies are the recipients of their governments' generous financial support, compared to that provided U.S. companies.

Domestic fuel cell manufacturers, in order to compete, must be able to offer power plants that use fuels which are available in the near- and mid-term. We can help them achieve this goal by improving the balance of our federal fuel cell R&D programs. Thus, while FCA fully endorses federal support for long term R&D aimed at the integration of fuel cells with coal gasification, (the current strategic approach of DOE's fossil energy program), and their eventual use in highway vehicles, (under the DOE conservation program), we strongly urge support for additional R&D to do the following:

1) enable fuel cells to effectively conserve currently-available fuels, such as natural gas and petroleum-derived fuels (propane, napthas, etc.)

2) permit fuel cell systems to use fuels expected to be available in the mid-term and/or to integrate such systems with fuels-production processes for that same time period. FCA would include methanol, biofuels, industrial organic and hydrogen waste streams, solar energy, and municipal wastes as examples of these fuels and fuels-production processes.

In view of the developing world-wide competition in fuel cells, the R&D priorities we recommend **should be initiated now.** The return on the U.S. government's investment in this technology will be enormously enhanced if our manufacturers are given the ability to enter a broad range of markets and to penetrate them at an expeditious pace.

DEMONSTRATIONS: Users in many of the above mentioned markets are very conservative, low risk-takers and want to see scaled-up demonstration units in operation before committing to purchases. Privately supported research organizations, such as the Electric Power Research Institute, the Gas Research Institute, and the American Public Power Association, do not have adequate funds to satisfy the requirements of the users. Consequently, the Federal government, in concert with developers, users, and the aforementioned private R&D sponsors, should create and support new technology demonstrations that respond, **not just to the requirements of the nascent fuel cell industry, but to the nation's pressing energy and environmental needs.** Until recently, the U.S. has been floundering at precisely this last and most critical stage.

Continuation of the federal government's policy of not supporting demonstrations will mean not only the loss of U.S. competitors in the diverse markets for fuel cells, but the loss of U.S.-developed technologies to overseas manufacturers. These fuel cell technologies will then be produced and exported back to us. Concomitantly, industrial employment, profits, and balance of trade will also suffer. We have seen this occur in the automotive, electronics, and computer industries, among others. The U.S. usually dominates new product discoveries, however, we let others bring our R&D advances to commercialization. We urge Congress to prevent this from happening in the field of fuel cells.

Fuel Cells Can Help Fill the Near-Term Power-Generating Needs of Electric and Gas Utility Industries

Because construction of new power plants has fallen behind, utility experts predict significant power shortages in the U.S. in the mid-90s. Nuclear power has faltered and coal-fired plants are under increasing pressure due to environmental concerns such as acid rain. Fuel cells have the potential to solve many of the problems now facing our electric and gas utility industries; in particular, they have unique advantages for the small, publicly owned utilities.

Fuel cells for utilities are expected to produce electricity at competitive costs. For example, fuel cells are projected to deliver power at costs as low as 5-6 cents/kWh using natural gas and at an even lower cost when eventually coupled to coal gasification. In a cogeneration application, an additional credit of approximately 1 cent/KWh may be realized since the thermal energy by-product can be a high quality source of process heat. These costs will be achieved when large numbers of fuel cells are purchased and produced.

Other advantages of fuel cells in this market include: factory-built, modular construction of fuel cell plants, which will facilitate a utility's ability to make rapid capacity additions or quickly meet customers' needs; ability to site fuel cell facilities in urban areas and close to users, thereby, eliminating the need to build expensive transmission lines on new rights-of-way; and multi-fuels capability that will enhance the security of electric power production. FCA is confident that, given the type of federal assistance we recommend, fuel cells will enter these markets within the next 3 to 5 years.

Fuel cells have no insurmountable technical barriers, but they must be encouraged to come down the "learning curve" in terms of market acceptance and production costs. FCA therefore urges Congress to continue its support for fuel cell R&D aimed at the electric and gas utility applications and, especially, scale-up demonstrations of this technology.

Fuel Cells Can Serve the Needs of the Transportation Sector

The transportation sector accounts for the majority (63 percent) of all U.S. oil consumption and is a major source of environmental pollutants, especially, in urban areas. Fuel cells offer the chance to **significantly reduce this enormous use of petroleum by our national transportation system while at the same time substantially reducing environmental impacts.** The transportation use of fuel cells is undoubtedly the most difficult among all potential applications of fuel cells and, without a commitment to long-term government encouragement, it may never happen in the U.S.: Congress should help assure this federal commitment.

DOE's transportation fuel cell program aims at demonstrating two applications: 1) a fuel cell-battery hybrid engine for urban buses for the near-term and; 2) a proton exchange membrane (PEM) system for eventual use in highway vehicles; both projects, we are pleased to note, have important contributions of support from other federal or state agencies. FCA is encouraged that significant progress has been made in the fuel cell/battery powered hybrid bus system in Phase I and that DOE has decided to proceed with Phase II. DOE's efforts for the PEM system has just begun with the release of a solicitation to industry.

FCA recommends that Congress and the Administration continue to foster industry/federal government cooperative programs of the type represented by these projects in order to speed the applications of fuel cells to our critically important transportation sector. In particular, we recommend that more than one contractor team be involved in the development of the PEM system in order to insure an adequate level of competition.

Fuel Cells Have Important Roles in Industrial and Building Systems Conservation and Renewable Energy

As one of the best fuel-conserving electric power technology available, Congress should insist that fuel cells play a prominent role in DOE's Industrial and Building Systems Conservation programs. Moreover, fuel cells can be integrated with various renewable technologies, such as wind, photovoltaic, solar thermal, and, particularly, biofuels, to enhance their systems' performances.

By conducting fuel cell R&D for these Industrial and Building Systems Conservation and Renewable applications, manufacturers will be able to enter these markets and increase their production levels. That is, they will be able to come down the "learning curve" and reduce system costs that much sooner. All users of fuel cell systems will therefore benefit. To ensure fuel cells are considered for these applications, FCA recommends that Congress provide modest levels of funding in FY1991 to enable DOE to assess the role of fuel cells in its Industrial Conservation and Renewables programs.

DOE FY1991 Budget

FCA presents its suggestions and rationale for the DOE fuel cell R&D budgets for FY1991 in the following paragraphs:

FCA'S RECOMMENDATIONS FOR DOE'S FY1991 BUDGETS

I. Fossil Energy

A. Phosphoric Acid Technology $ 6 Million

Phosphoric acid technology is the most developed of all fuel cell technologies. Funding of $6 million is required to bring this technology to commercial reality by building and testing two air-cooled 375-kW modules.

B. Molten Carbonate $26 Million

FCA strongly urges support for development of this most attractive fuel cell technology. In particular, we urge funding of $16 million to continue the two cost-shared system/stack contracts selected under the FY90 competitive solicitation and $4 million to continue stack research with the third developer. FCA recommends the sum of $2 million for support of molten carbonate base technology activities both in industry and DOE laboratories. The Association urges $4 million to initiate an industry-government cost-shared project aimed at qualifying a megawatt-sized MCFC plant by FY1993.

C. Advanced Concepts $8 Million

FCA recommends allocating $5 million to continue cost-shared technology development on tubular Solid Oxide Fuel Cells and $3 million for technology for other advanced concepts, including the monolithic concept.

D. Advanced Research Technology Development $2 Million

This level of support will provide the opportunity to perform generic applied research in basic electrochemical science and to investigate new, low-cost concepts to improve fuel cell system performance.

Total for Fossil Energy: $42 Million

II. Transportation Conservation

A. Fuel Cell-Battery Bus Program $3.5 million

Based on the significant progress made in Phase I, FCA recommends that Phase II of the fuel cell/battery bus program be supported. This cost-shared effort will require $3.5 million in order to fully fund the integration of a full-size phosphoric acid fuel cell/battery propulsion system into a testbed bus and to demonstrate proof-of-concept.

B. Proton Exchange Membrane (PEM) Development Program	$5.0 million

DOE is in the process of initiating a Proton Exchange Membrane (PEM) fuel cell technology program for transportation applications. The PEM fuel cell could offer major improvements in power density over the phosphoric acid fuel cell used for the bus application. Under Phase I, the program would demonstrate a 5 kW "breadboard" system and conduct R&D leading to a fast-response reformer, the latter eliminating the necessity for a battery. Funding of $5 million should be provided for FY1991.

C. Applied Fuel Cell Research	$3.5 million

Last year, Congress requested that DOE's Energy Storage fuel cell applied research be transferred to Conservation's transportation program, a move FCA felt would better focus the efforts. FCA therefore recommends that $3.5 million be provided to the transportation program in order to support such activities as: PEM fuel cell applied research; technology for the direct oxidation of methanol; and joint industry/government projects aimed at understanding basic fuel cell phenomena, including corrosion.

Total for Transportation Conservation:	$12.0 million

III. Industrial and Building Systems Conservation and Renewables

$2 Million in funding is recommended to evaluate the incorporation of fuel cells into commercial, industrial and building systems applications using the basic technology now being developed for utility-sized plants. Also, $1 million is recommended to study the incorporation of fuel cells into biofuels, wind energy, photovoltaic, and other renewable sources.

Total for Industrial and Building Systems Conservation and Renewable Energy:	$3.0 million

TOTAL FY 1991 DOE FUEL CELL PROGRAM RECOMMENDED BY FCA:	$57.0 million

Concluding Remarks

The Fuel Cell Association is a not-for-profit business organization comprising over 60 corporate, institutional, and associate members. The aim of our Association is to speed the development and commercialization of all fuel cells. FCA appreciates the opportunity provided by the Committee to present its viewpoint on the efforts and funding needed to bring this clean, power generation technology to commercial reality.

Hydrocarbon Research, Inc.
100 Overlook Center, Suite 400
Princeton, New Jersey 08540
609/243-8700 Fax 609/987-0204

Allen S. U. Li
Vice President

June 26, 1990

The Honorable Marilyn Lloyd, Chairman
Subcommittee on Energy Research and Development
Science and Technology Committee
U.S. House of Representatives
Washington, D.C. 20515

Dear Madam Chairman:

Hydrocarbon Research, Incorporated appreciates the opportunity to comment as part of the Subcommittee's June 25 hearing record on the role of federally funded research and development in coal liquefaction technology.

Hydrocarbon Research, Inc. (HRI) has played a key role in the Research and Development of coal liquefaction over the last thirty years. In recent years, through the support of the United States Department of Energy, HRI has made significant advances in both our Close-Coupled Two-Stage Liquefaction of Coal (CTSL) Technology and in our Coal/Oil Co-Processing Technology. Specifically, the following breakthroughs have been made which have drastically cut the production costs and increased the quality of the liquid fuel product:

- Increased Liquid Yield by 50%
- Increased Selectivity to Gasoline & Diesel
- Decreased Sulfur Content to 0.01 wt%

HRI's CTSL Technology is in the final stages of scale-up, under Contract No. DE-AC22-88PC88818, and requires funding at the level of $3 million for fiscal years 1991, 1992 and 1993. This will complete the program which started in 1983 and provide a firm basis for commercial demonstration.

With regard to the Co-Processing Technology, we have been conducting Research and Development over the last four years with financial support from the Department of Energy, EPRI and private industry in Canada, Germany and Japan. HRI understands that funding for this program is in jeopardy just at a time when we are seeking to complete its development with our private industry partners. Funding at a level of $3 million annually over the next three years, with a minimum of $1 million in contribution from the private sector, will lay a solid foundation for commercializing this important technology.

Halting these programs at this point would be a terrible blow to our nation's Fossil Energy Program. While we have made great strides in the last several years, scale-up is required to minimize technical risks and provide confidence to investors who seek to move these technologies to the marketplace.

Support from this Subcommittee, others in Congress and the Administration will ensure ~~the~~ continued development of a technology that can provide environmentally clean transportation and utility fuels from a strategic domestic resource.

In closing, Madam Chairman, HRI would like to thank you and the members of the Subcommittee for your support of federal funding for important energy research and development projects, and in particular for your continuing support of coal liquefaction R & D efforts.

Sincerely,

Dr. Allen S. U. Li, D.Sc.
Vice President, Technology

ASUL/sb